ENGINEERING

An Illustrated Weekly Journal

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ENGINEERING

An Illustrated Weekly Journal

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WORLD FERMENT

THE wealth, the power and the prestige of the world's major industrialised nations have given to the development of manufacturing industry in under-developed countries a glamour which sometimes blinds these countries and their friends to the enormous problems involved. Strangely enough, idealists of the Left and crude believers in the American way of life have both sometimes seemed to fall into a common error—believing that the problem of the appalling poverty in these countries was one that could be solved by purely materialistic means, whether of financial aid or investment. Greater experience since the war has shown how inadequate such proposals are. In 1953 the Economic and Social Council of the United Nations requested the Secretary-General to prepare a study* of the processes and problems of industrialisation. Although submitted as an introductory document, it is a substantial study of the obstacles to the domestic and international methods conducive to, and the economic and social results of, industrialisation.

The anxiety of governments in many of the under-developed countries to industrialise can be better appreciated when the disparity between the volume of factory goods available per head in industrial and in less-developed countries is realised. In the prosperous years 1926-1929, for example, in order to raise the supply of factory goods per head in the less developed two-thirds of the world to only one-half that in the 25 most industrialised countries, the inflow of manufactures to the former would have had to rise 16 times, or twice the total annual value of all international trade. Nevertheless, the first task in raising living standards may not be achieved by the establishment of secondary industries. The circumstances differ from country to country according to whether there are potential raw materials and sources of power and whether there is a surplus of population on the land.

Too rapid industrialisation may increase the demand for food faster than it can be produced. An increase in agricultural production must, therefore, take place parallel with the building of factories. Equally important are the prior development of the overhead facilities: transport, power, water, housing. The development of secondary industry itself can be expected to take place in three stages: the preparation of primary materials, their pre-formation and fabrication, and the manufacture of capital goods. But investment in these industries will not be profitable unless the basic facilities have been provided and this must generally be done by government. In addition, because of their heavy capital cost, governments must generally participate in the establishment of such basic manufacturing industries as iron and steel.

The difficulties which under-developed countries face, which are well brought out in this report, are an intricate mixture of social and economic factors. The countries of Western Europe went through a long period of social change before the industrial revolution, during which a commercial middle class came into existence capable of acting as entrepreneurs. Economically, industrialisation was preceded by the growth of banking and commerce and by a scientific revolution in agriculture. Populations at the beginning were low, so that the problem of food supply only appeared for short intervals. Even so, the crowding of peasant populations into the towns caused great suffering.

In many of the under-developed countries the social structure is quite unprepared for industrial change. Large parts of their populations live in closed family or village groups with non-market economies of near-subsistence type. Classes are rigidly stratified and the values of society are primarily non-economic. As a result, there is a lack of sources of industrial leadership and capital. The wealthier class are likely to spend their surplus incomes on conspicuous consumption, and even the peasant, if he has any surplus, may use it to buy cattle for prestige rather than for marketing, or to buy more land even if it cannot be profitably worked.

The political systems and lack of a trained public administration are a deterrent to investment of either domestic or foreign capital. There is generally an inadequate service of statistical data on which to base investment plans; and yet any such plans must take account of the problems of availability of labour, sources of recruitment, incentives for mobility and facilities for training. The source of capital equipment must largely be the industrialised countries. Many under-developed countries are primary producers and their ability to buy such equipment, apart from foreign investment, depends on the prices they receive for their products, and they would therefore be considerably helped by international agreements to stabilise commodity prices. Most capital equipment is designed in advanced countries and may be too complicated for use by the relatively unskilled labour in the less advanced; in fact, one of the problems these countries face is that they are trying to industrialise at what is already a very high technological level. What is often needed

* *Processes and Problems of Industrialization in Under-Developed Countries.* O.E.E.C. H.M. Stationery Office, Kingsway, London, W.C.2. (11*s.*)

are the improvement of small-scale and handicraft production by the use of improved tools and, where electrification has taken place, the introduction of small machines. This is particularly important where there is a surplus of population. It is at first more necessary to encourage industries which are labour-intensive, rather than those which are capital-intensive.

The report gives a serious warning on the social effects of too rapid industrialisation; although it points out that to-day our greater knowledge ought to enable these countries to avoid the mistakes of the industrial revolution in Europe. The problem is to avoid transferring social habits and living conditions, which were just tolerable in the villages, to the overcrowded towns. The enormous populations of some of these countries and the speed of the change make the problem even more serious than it was in England in the Nineteenth Century. One particularly distressing feature is the break-down of village and family customs of mutual aid and communal co-operation, even among kinsfolk, where they are undermined by the exchange system on which the development of secondary industry depends. It takes time for new habits of association to develop and it is interesting that a distinctive feature of the co-operatives, mutual aid societies and trade unions which develop under these conditions is that they readily expand into a movement of general social reform and play an important part in establishing new social standards, in reorientating individuals and in reconstructing local communities.

A section of the report is devoted to the change in the pattern of foreign trade in the light of the experience of Australia, South Africa and three South American countries. The same changes in the nature of imports have occurred in all five countries, whether their economies were more or less subject to government control, and the general conclusion is that it is by no means certain, as some economists proclaim, that industrial development in the less-developed countries will result in an expansion of international trade.

Weekly Survey

Cover Picture. *To reduce the frictional losses, and to ensure water-tightness, rock-bored tunnels must be lined, for which purpose easily moulded concrete is particularly suitable. The cover-picture shows the concrete lining being introduced into the soffit of one of the twin* 45-*ft. diameter tunnels, each* 5½ *miles long, at the* 1,370-*MW Sir Adam Beck-Niagara Generating Station of the Hydro-Electric Power Commission of Ontario. Now completed, the tunnels bring* 15 *million gallons of water each minute from the intakes above the Falls to the power-house forebay area.*

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COMPARING PRODUCTIVITY

Output per man-year in the United Kingdom increased by 3 per cent. during 1954, and the corresponding figure for industry alone is about 4½ per cent. The latest issue of *Bulletin for Industry* issued by the Treasury Information Division points out that this increase is better than the post-war average, although not a record, and that it is normal for productivity in industry to increase slightly faster than productivity in the economy as a whole.

The Bulletin makes two interesting sets of comparisons by listing major industries in order of their increased productivity between 1948 and 1954, and by making some international comparisons. Within the manufacturing groups, the largest increase is recorded by chemicals, with an 8 per cent. advance. Following this are two smaller industries, and then come motor vehicles with 4½ per cent. and engineering (including shipbuilding and electrical goods) with 4 per cent. It is interesting to note that the very large capital investment programme in the chemical industry since the war has resulted in a correspondingly large increase in output per man-year whereas the increase in iron and steel (where there has also been an outstanding programme of expansion in recent years) has been only 3½ per cent.

Figures issued by the Economic Commission for Europe show that output per employee-hour in industry in this country has increased favourably when compared with other European countries between 1938 and 1954. In the last few years, however, Germany, France and the Netherlands have been catching up. To some extent this has to be expected, since the economies of all three of these were severely damaged during the war and began their post-war reconstruction later than the United Kingdom.

E.C.E. has also compared the increase in the volume of capital investment (in the sense of fixed investment) between 1950 and 1953. Over those years fixed investment in this country increased by 12 per cent., compared with 26 per cent. for Germany and 3 per cent. for the United States. If the housing figure is excluded from the U.K. percentage, however, the rise was only 1 per cent. It remains to be seen how far the increased emphasis on capital investment for industry improves the fixed investment figure, excluding housing, for 1954 and 1955.

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EARTHMOVING EQUIPMENT

It must not be assumed too readily that the growing volume of constructional activity is opening up an era of unprecedented prosperity for British manufacturers of earthmoving equipment and contractors' plant. Certainly, sales have been increasing (total British output of earthmoving machinery and parts at £33·3 million in 1954 was about 6 per cent. higher than in 1953), but production for export, at £14·1 million, was about 5 per cent. down, and increasing competition at home and abroad greatly reduced profit margins. The recent statement of Mr. J. M. Wallace, chairman of Blaw Knox, Limited, shows that his company's experience was not exceptional. Sales of the Construction Machinery Department were up, but higher production costs in the more competitive market reduced profitability, and it was due largely to the outstanding results of the department responsible for the production of transmission and radio towers that the company's trading profit increased by about £21,000 to £428,000 in 1954. The Tower Department, who have many valuable export orders and had a record turnover in 1954, should have an equally successful year in 1955.

The success of the Construction Machinery Department will depend on their ability to hold their own in design and development in an industry in which the pace of evolution is rapid. Large rewards are to be won by the manufacturer who can offer outstanding designs at low cost. Price is becoming increasingly important, particularly for such standard lines as graders and the smaller excavators. Competition is very keen at home, and abroad manufacturers have to contend with U.S. manufacturers whose large home market and long years of experience have enabled them to produce in quantity machines which combine cheapness and simplicity with robustness. Blaw Knox are well placed to contend successfully with the competition. Constant improvement has kept their equipment in the forefront of design. At the Public Works Exhibition in November, their new models included a more powerful grader—the "Super-12" for extra-heavy duty driven by a 118-brake horse-power engine—and a new BK-50 excavator which incorporates many additional features to give speedier and more economical working in their established standard ½-cub. yd. excavator. Their American association is a source of considerable strength to the British company; close contact with the Blaw-Knox Company, Pittsburg, ensures that their new products have behind them the widest American as well as British experience.

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SCOTTISH ENGINEERING

The Scottish engineering industry prospered in 1954. The output of vehicles increased by 10 per cent. compared with 1953 and production of precision instruments went up by as much as 23 per cent. General engineering showed an advance of 11 per cent. while shipbuilding maintained the same level as in 1953.

The only section to show a significant fall was metal manufacture, where a decline of 4 per cent. on the previous year's rate of activity was recorded. This decline, however, appears to have been concentrated on the steel industry where the output of ingots compared unfavourably with 1953 until the closing weeks of the year. The same was true for plates and light rolled products at the finished end of the industry.

Industrial production in Scotland as a whole increased by 5 per cent. over the year and the major share of the advance was recorded by the engineering industry in its export markets. To some extent Scotland shared the same experience as England so far as the rate of increase in the output of capital goods was concerned. In most sections of the engineering industry this slackened off in the second half of the year. This year, however, the rate of advance might well increase. There are signs that the steel industry is increasing its output once more and Scotland is likely to get its share of the increased building activity scheduled for 1955. Prospects for engineering in Scotland are generally good, but the pattern of expansion might be more like 1953 than 1954. In 1953 it was the home market which provided most of the impetus for expansion and this market rather than exports is likely to lift the production of capital goods to a new high level in the current year.

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PHYSICAL SOCIETY EXHIBITION

Measurement must necessarily be the major theme of any exhibition concerned with physical science; but since measurement provides a basis for almost all technical development, such an exhibition will serve too as a guide to current progress in technology. If, for example, an instrument for checking turbine blades is in demand, then it is reasonable to suppose that the turbine industry itself is active. The annual exhibition of the Physical Society has thus a special interest for engineers.

The 39th Physical Society Exhibition will take place from Monday, April 25, to Thursday, April 28, and is to be held at the Royal Horticultural Society's New Hall and not at Imperial College as hitherto. The exhibits to be shown there will range from research apparatus for the investigation of newly discovered scientific principles to manufactured instruments in which such principles are applied, and among the fields covered will be electronics, computing

equipment, the study of materials including soils, metals, liquids and gases, optics, nuclear physics, testing machines and measuring devices, mechanics and the science of colour. Some of the exhibits to be displayed are described on a later page in this issue.

If these various items represent lively spheres of technical activity, what inferences can be drawn? Certainly, the number of magnetic "stores," delay lines and calculating circuits to be exhibited suggests that a wide interest in computers and other automatic machines exists. This view is confirmed by the selection of "Memory Systems in the Brain" as a subject for one of the three discourses to be given during the period of the exhibition.

The two other discourses will deal with "The Free Electron as a Tool in Scientific Research" and "Recent Developments in Luminescence and Its Applications," and these may likewise offer ground for speculation. But what conclusions arise from the main body of small exhibits? What new instruments indicate the growth of new technologies? Perhaps, for example, the colorimetric devices to be shown at the exhibition herald the advent of colour television in this country.

* * *

CROFTS ENGINEERS

The rising prosperity of the British engineering industry has naturally created increased demand for power transmission machinery and appliances, and it is not surprising that turnover and profits of one of the largest manufacturers of these in the world, Crofts Engineers (Holdings) Limited, have expanded rapidly in the past few years. The Group, whose main works at Thornbury employ over 2,000 people, increased their profits in 1954 to £854,000 compared with £769,000 in 1953 and £536,000 in 1948. There is, of course, an increasing tendency for manufacturers of machinery to cut their own gears and, where reasonably simple, to make their own transmission systems; but with the increasing complexity of transmission systems, they are also buying more from specialist producers.

The rate of technical progress in transmissions is particularly rapid and the specialist producer cannot afford to stint expenditure on research and development in order to keep their products competitive. Crofts are also undertaking heavy capital outlay to improve their production facilities. Extension and re-organisation schemes at Thornbury and Dudley Hill were completed in 1954, and the chairman, Sir Arthur Croft, said in his recent statement that the company are now committed to a capital expenditure of £243,000. Although most of this will be spent in 1955, deliveries of new plant and machinery will extend over the next few years. Crofts have found that a policy of providing more technical service to industry is producing good results and with good order books can look forward to the future with considerable optimism. The Group, whose products were already sold to a large section of the industry, further extended their interests in 1954, by acquiring two new subsidiaries, J. Parkinson & Son (Shipley) Limited, and Carter Gears Limited, of Thornbury. The former are makers of milling machines and gear-cutting machines as well as the Parkinson patent vices and their gear-testing machines, etc. Carter's patent hydraulic variable speed gears will be a useful supplement to Crofts' present range of power-transmission equipment.

* * *

ELECTRIC TRACTION

The fact that the use of electric traction on British Railways is at present comparatively limited, and that under the modernisation and re-equipment programme only a beginning—although a fairly substantial one—is being made towards its wider adoption, makes it difficult to realise that its advantages have been recognised for a very long time. The principal British manufacturers of electrical equipment have experience of it dating back for half a century, and a recent information circular of the General Electric Company points out that the company had been supplying motors and control gear for tramways for two decades before that; their association with London Transport railways is of very long standing. The company have recently received an order for 32 complete 1,500-volt equipments for four-coach trains to operate on the Chelmsford and Southend extensions of the Liverpool Street to Shenfield electrified line. The further extension of electrification to Ipswich, including the Clacton, Harwich and Felixstowe branches, is one of the three schemes in the modernisation plan which will, in total, require 1,100 main-line electric locomotives costing £60 million. In addition, 3,600 multiple-unit electric vehicles are required for suburban as well as these main-line schemes.

Such a volume of work is as much as the manufacturers can reasonably be expected to cope with. They already have large export orders and are also heavily committed with the Diesel-electric programme. Among the most important export orders is a contract worth £7 million placed with the Metropolitan-Vickers Electrical Company for the supply of 100 electric train units for Rio de Janeiro. Metropolitan-Vickers have already supplied the electrical equipment for the 65 locomotives at present in use on the recently completed Manchester-Sheffield line, the first main-line on British Railways to be electrified for both passenger and freight traffic. The English Electric Company also have been particularly active overseas, and their export orders have included sixty 3,600-h.p. electric locomotives for Spain and twenty-five 2,400-h.p. locomotives for the Victorian Government Railways. Their contribution to British Railways' modernisation programme includes power equipment for electric locomotives as well as the well-known 2,000-h.p. Diesel-electric main-line locomotives and 400-h.p. shunting locomotives.

* * *

NEW LEADERS IN THE CAR INDUSTRY?

The growth of the Ford Motor Company's output since the war, from 152,000 vehicles in 1948 to 291,468 vehicles (including about 45,000 tractors) in 1954, is mainly the result of a higher utilisation of available floor space through increased employment, overtime and some shift work, although improved production flow mechanisation played their part. In the chairman's own words: ". . . from factories only slightly larger than before the war, our production has trebled." The company are now embarking upon a large programme of expansion to increase their factory area from 6 million to 10 million sq. ft., but further progress in improving machine utilisation may yet produce increased output this year before the new buildings are up. There is, by all accounts, some leeway to make up, even by Ford, if the machine utilisation of some Continental firms, such as Volkswagen, Fiat and Renault, is to be matched.

Ford's output last year was far higher than any of their British competitors, none of whom reached 200,000 vehicles. They were only 22 per cent. behind the combined output of Austin and Nuffield which totalled about 370,000 vehicles. The British Motor Corporation have also announced expansion plans, in common with most other companies in the industry, and it would be idle to speculate on the relative position of the leaders two or three years hence. When the industry's expansion catches up with demand, and this is likely during that period, a bitter competitive struggle may well take place, and in this the manufacturing dispositions of the contestants could be of the greatest importance. Fords employ at Dagenham 36,000 of their total labour force of 43,000, and enjoy a relatively very good concentration of production facilities. Any large increase in the number employed at Dagenham might strain local resources (probably at other companies' expense) but the choice of Woolwich Arsenal for further expansion—where redundant R.O.F. labour will be available—is a good one. A large part, however, of the 4,000 additional employees estimated to be required will be needed at the machine shop being erected at Basildon New Town.

Despite the unusually large proportion of motor components made by Ford, 56·7 per cent. of turnover last year consisted of purchases, although much of this was raw materials such as iron ore, coal, glass and steel. It would be difficult for Ford to reduce further the proportion of bought-out components, since major items such as tyres and electrical equipment, which do not easily lend themselves to relatively small-scale production. The incentive would have to be a very strong one indeed.

* * *

NEWSPAPER DISPUTE

After a particularly gloomy outlook during the week-end, the dispute in the London newspaper industry assumed a cheerful aspect last Monday, following a meeting at Transport House attended by representatives of the printing and striking unions and presided over by Mr. C. J. Geddes, C.B.E., the chairman of the Trades Union Congress. Until then, there had been little sign of any break in the deadlock between the Amalgamated Engineering Union and the Electrical Trades Union, on the one hand, and the Newspaper Proprietors' Association on the other. In spite of sustained efforts by conciliation officers of the Ministry of Labour and the pleas of the Trades Union Congress, the strike by some 600 maintenance men and electricians belonging to the A.E.U. and the E.T.U. had continued.

It entered its fourth week last Friday, with the result that over 20,000 newspaper employees in London became idle on that day, on the expiry of their notices from the Newspaper Proprietors' Association. The stoppage is estimated to have cost the newspaper industry so far between £2 million and £3 million. The trouble began in mid-March when the two unions concerned refused to accept a substantial wage increase offered by the Newspaper Proprietors' Association and asked, instead, for an advance of £2 18*s.* 6*d.* on the men's basic weekly rates, in order to bring these rates up to about 125 per cent. above the pre-war level.

Following the initial failure of the Ministry of Labour conciliation officers to affect a settlement of the dispute, the Minister appointed a three-man committee under the chairmanship of Sir John Forster, on April 4, to act as a court of inquiry for the investigation of the points at issue. In their report, published nine days later, the court had some hard things to say about the striking unions. They considered that "the precipitate action of local officials in calling an unofficial strike was unjustified," and that it was "most regrettable" that the two unions did not submit their claims to arbitration.

The principal proposal of the court was that the 14 unions catering for employees in the newspaper industry should set up a central body to conduct negotiations on matters relating to wages and working conditions in the industry, and that, pending its formation, the engineering employees, electricians and electricians' assistants "should return to work, without prejudice, on the basis of the employers' present offer." Suggestions for the establishment of a central negotiating body by the employees was substantially put forward by the Newspaper Proprietors' Association at the court's public hearings.

At last Monday's meeting under Mr. Geddes' chairmanship, union representatives, including officials of the P.K.T.F., decided to approach the Newspaper Proprietors' Federation on the following day to explore the possibility of a settlement. It is understood at the time of going to press that the two striking unions no longer insist on an explicit undertaking that more money will be forthcoming. The world has been without London's national newspapers since March 25.

Letters to the Editor

GAS-TURBINE PRINCIPLES AND PRACTICE

SIR, Your reviewer, in his comments on *Gas Turbine Principles and Practice* (page 333, March 18), writes: "A serious error occurs in the discussion of the calculation of velocities in impeller channels on page 6-10, where it is stated that radial equilibrium exists. This is definitely not the case." I did not make any statement about radial equilibrium, and can only judge that your reviewer has based his remarks on the expression I gave for the pressure gradient, which is often derived for the case of equilibrium with zero radial velocity. But with radial vanes, for example, it also covers the case of a constant radial velocity. For this type of impeller the full general expression using simple theory would be :—

$$\frac{dp}{dr} = \frac{\rho\omega^2 r}{g} - \frac{\rho}{g} V_r \frac{dV_r}{dr},$$

(where V_r is the radial velocity, and ω the angular velocity of the fluid), which reduces to the form I gave for the case of a constant radial velocity.

In most practical cases the changes in mean radial velocity are such that the second term is small compared with the first, and may be neglected. For the case of curved vanes with reasonable curvature the subsidiary terms are also unimportant, so that the original expression would be generally useful where estimates of mean flow conditions are considered to be of value. While it might have been wiser to explain the approximations involved, the omission is scarcely as serious as your reviewer suggests.

Any question of a full treatment would, moreover, involve consideration of the circulations mentioned earlier in section 6 and in section 9, the geometry of the impeller, and the important effect of the entry conditions on the channel flow. In the case of a centrifugal compressor the practical value of the results from such a treatment would bear little relation to its complexity.

Yours faithfully,
L. J. CHESHIRE.

The Spinney,
Church Walk,
Bilton,
Rugby.
April 7, 1955.

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REORGANISATION OF THE COAL BOARD

SIR, The reconstructed Coal Board, in addition to giving attention to departmental organisation, is creating three new departments, for staff, industrial relations, and purchasing, and the Fleck Committee's views for the improvement of management at all levels have been accepted. It has been abundantly clear, however, that for many years the major weakness has lain in the sphere of industrial relations, a weakness only matched by the absence of any conception of the management function in industry.

In a book under my name, *The Economics of the Coal Industry*, reviewed in your journal in 1930, one chapter, "Partners in Industry," was an analysis of human behaviour in the coal industry. Since then, I have stressed in many papers and lectures the overwhelming necessity for paying the closest attention to the human factor—two of which may be quoted: "Human Relations in the Mining Industry" (*Colliery Engineering*, 1948) and "Restoration of Productive Efficiency in the Coal Industry" (*Proc. National Association of Colliery Managers*, 1949).

At long last, wiser counsels have prevailed, and one wishes the Coal Board well in these issues that require tolerance and vision as correctives to over 9,000 strikes since 1947, and loss of output of 80 million tons per annum, through ca'canny, and "go slow." The matter has a two-fold aspect, however, for the Board can never hope to build upon sound foundations so long as there is, as at present, an absence of training for management. In the sphere of management, the field for development is of equal value and importance to that in industrial relations. Indeed, the whole question of industrial behaviour is bound up with recognition of the management function by the industry. The Fleck Commitee's report is quite clear and definite in that respect.

Finally, appropriate measures have to be undertaken by the National Union of Mineworkers in the field of human relations, if success is to be achieved and an orderly pattern of integration created.

Yours faithfully,
R. C. SMART.

Shaftesbury Buildings,
61 Station-street,
Birmingham, 5.
April 8, 1955.

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THICK-WALLED CYLINDERS UNDER INTERNAL PRESSURE

SIR, My attention has been called to a letter from Dr. Blair in your issue of February 25, in which he makes some comments on the theoretical treatment of this problem given in the article you published in 1945 (vol. 159, pages 101 and 183). He refers to this at one point as "Manning's formula" and goes on to say that "it is not likely to appeal to practical workers."

It may well be that he is justified in dismissing my earlier efforts in this summary way, although I think it is not unfair to point out that he himself consistently advocated a rather unwieldly formula until the recent work of Crossland and Bones showed it to be untenable. I might add that some experimental data I offered in a letter you published in 1945 (vol. 159, page 435), raised at least a considerable doubt as to its validity.

Dr. Blair now recommends the "mean-diameter formula," but it is surely a fact that he can only afford to do this because of the experimental data that have since become available. Where materials or conditions are untried, a more fundamental approach seems essential. I should like to illustrate this by recalling the position in which my colleagues and I, in the Alkali Division of I.C.I., found ourselves 20 years ago, when called upon to devise a satisfactory design technique for an industrial process to work at a pressure well in excess of any then operating. Virtually our only background was the ordinary text-book theory, and the published work of Bridgman and Michels, the latter supplemented by personal contact with the author. These could not be considered adequate in themselves, and we certainly could not have relied on any empirical formula not tested under the required conditions. It was eventually decided, partly from theoretical considerations and partly as a result of extensive small-scale experimentation, to base the design, not on the elastic limit, but on the ultimate bursting pressure of the cylinders concerned. We defined this as that pressure which would eventually cause failure if maintained for a long enough period. There were several reasons for adopting this rather unusual design basis, the most important being the saving in weight which it permitted. But to be able to use it with confidence we had to know the ultimate bursting pressures accurately, and these were soon found to be difficult to determine by experiment. The trouble was that the test cylinders always tended to burst at too high a pressure, probably because the loading rate was not slow enough to allow an equilibrium state to be reached; and errors of this sort would produce designs that erred on the side of danger.

It was therefore considered that the first need was to evolve some means of estimating the ultimate bursting pressure over a range of sizes and materials and then to check them by a few experiments which could be carried out with special care. The theory that Crossland and Bones have now confirmed was the result, and it had the further justification of enabling—or at least facilitating—the rapid design and construction of the required plant at a time when the urgent manufacture of its product was supremely important and may even have changed the course of history. Incidentally, the resulting technique has stood the test of more than 15 years commercial operation.

This theory is admittedly elaborate to apply and cannot be condensed into a "formula," although, when once a curve relating ultimate bursting pressure and diameter ratio for any one material has been worked out and checked by a few experiments, the subsequent design procedure is extremely simple. I make no special claim for it except that it has a fundamental basis which the mean-diameter theory, as far as I can see, has not, and I submit that neither Dr. Blair, nor any other responsible engineer, could confidently use the latter, if called upon to design cylinders or tubes in a material in which it had not been adequately checked by experiment. To do so would be to court disaster.

Yours faithfully,
W. R. D. MANNING.

Red Cottage,
Townsend-avenue,
St. Albans.
April 15, 1955.

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ADHESIVE-BONDED AIRCRAFT JOINTS

SIR, Mr. Jablonsky adds nothing, in his letter published last week, to the evidence that has been fully examined by the officially appointed public inquiries into the Comet accidents. He does, however, affirm that there was no evidence, established by appropriate research work in the R.A.E. report, to show that the difference in temperature between the outer skin and the stiffener glued to the skin was only 10 deg. C., and he continues to state ". . . even if the difference is only 10 deg. C. at the end of the climb from tropical to arctic conditions, it must be remembered that the outer thinner skin will react much more quickly under changing conditions than the interior stiffener of heavier gauge and this delaying factor is bound to result in differential movement between the two during exposure to a swift change between extremes of temperature. However, my contention is that the difference in temperatures immediately after a fast climb is substantially greater than 10 deg. C." These views may be answered briefly as follows:—

(1) The R.A.E. Report on Comet Accident Investigation, Part 10, "Flight Investigation on Comet G-ANAV," Appendix 10, states "No high temperature levels were recorded and no significant gradients found. In the main the skin temperatures followed ambient and the temperatures on the inner faces of stringers and frames were no more than 10 deg. C. higher." If Mr. Jablonsky doubts that these findings were established by appropriate research work, he will be glad to learn that the figure of 10 deg. C. is not critical or even strictly relevant since tests have shown that, with a temperature differential of even 90 deg. C., equilibrium between the inner and outer skins was reached in only a few seconds.

(2) It can be deduced that the rate of temperature change during the climb of the Comet is not greater than 4 deg. C. per minute, and this can hardly be termed "a swift change."

Some of the further research required by Mr. Jablonsky had in fact already been carried out before the Comet accidents and it should be appreciated that a great deal of the work that had been done was not called for as evidence during the inquiries.

Yours faithfully,
for Aero Research, Limited,
K. S. MEAKIN.

Aero Research, Limited,
Duxford,
Cambridge.
April 18, 1955.

PERSONAL

VISCOUNT WEIR OF EASTWOOD, P.C., G.C.B., LL.D., Hon. M.I.Mech.E., has intimated his intention to retire from office as director and chairman of G. & J. Weir, Ltd., Holm Foundry, Cathcart, Glasgow, S.4, with effect from the date of the annual general meeting of stockholders. His association with the company extends over 57 years.

MR. S. H. HOLE, M.I.Mech.E., has been elected a vice-president of the Junior Institution of Engineers in recognition of his many services, especially in connection with the acquisition and equipment of the new headquarters of the Institution at Pepys House, 14 Rochester-row, London, S.W.1.

SIR PERCY H. MILLS, Bt., K.B.E., has joined the board of Lancashire Dynamo Holdings Ltd., and MR. J. G. SHAW has resigned from the board. Mr. Shaw, however, remains a director of some companies within the Lancashire Dynamo Group.

MR. F. A. KING and MR. A. J. HUGHES have formally retired from the board of Kelvin and Hughes Ltd., after some 60 years of service with the company. MR. F. W. BATES, who first joined the firm as an apprentice in 1927, and later became general works manager, has now been appointed to the board.

MR. W. N. KILNER, M.I.E.E., is now chief engineer of the newly-formed turbo-generator engineering department of the Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17. MR. C. P. HOLDER, B.A., M.I.E.E., is assistant chief engineer of the plant department, and MR. E. NICHOLSON M.B.E., T.D., B.Sc., A.M.I.E.E., is assistant chief engineer of the switchgear department of the firm.

In addition to the appointment of MR. W. B. G. COLLIS, M.B.E., T.D., B.Sc., A.C.G.I., A.M.I.E.E., as manager of their traction department, announced on page 392 of our issue of April 1, the British Thomson-Houston Co., Ltd., Rugby, have decided to reorganise that department to cater for the expanding growth of railway electrification. MR. J. H. CANSDALE, M.I.E.E., in addition to his duties as deputy manager, traction department, will be primarily responsible, in future, for all contracts. MR. M. W. T. REES, B.Sc.(Eng.), A.M.I.E.E., Assoc.I.Mech.E., has been appointed assistant manager (projects) of the traction department.

MR. F. A. HURST, chairman and managing director of Samuel Osborn & Co., Ltd., Clyde Steel Works, Sheffield, 3, has been elected President of the Sheffield Chamber of Commerce. He will be installed on April 28.

MR. J. W. HOWLETT, O.B.E., M.I.Mech.E., founder, chairman, and managing director of Wellworthy Ltd., Lymington, Hampshire, has had conferred upon him the honorary freedom of the 800-year old Borough of Lymington. This is only the third time in its history that Lymington has conferred this honour.

MR. W. NEWMAN ALCOCK, 57, Dumbuck Crescent, Dumbarton, informs us that the Council of the Royal Aeronautical Society have awarded him an R38 Memorial Grant of £50 in order to assist him in his work on airship research.

MR. TIMOTHY ELLIS has been appointed an assistant secretary to the General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2, as from March 24.

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COMMERCIAL

The products previously sold under the names of E.M.I. FACTORIES LTD., E.M.I. ENGINEERING DEVELOPMENT LTD., and E.M.I. RESEARCH LABORATORIES LTD., are now being handled by E.M.I. ELECTRONICS LTD., Blyth Road, Hayes, Middlesex (Telephone: SOUthall 2468). The products themselves remain unchanged.

A new battery factory, at East London, Cape Province, South Africa, owned by the CHLORIDE ELECTRICAL STORAGE CO. S.A. (PTY.) LTD., an associate company of CHLORIDE BATTERIES, LTD., Exide Works, Clifton Junction, near Manchester, is now in production.

FINNEY PRESSES LTD., a member of the Metal Industries Group of Companies, have been granted a licence to manufacture in Great Britain, the plastics rubber and continuous vulcanising machinery produced by DAVIS-STANDARD SALES CORPORATION, of Mystic, Connecticut, U.S.A. The company is to market this range of machinery in Europe and throughout the Sterling area. MR. H. M. WHITCUT is shortly to join Finney Presses Ltd.

SUNVIC CONTROLS LTD., 10, Essex Street, Strand, London, W.C.2, announce with regret the death, on April 7, of MR. G. R. PEEKE, of Birmingham, their Midlands representative for scientific and industrial products. They request that, for the time being, all inquiries and correspondence should be addressed to the company, at No. 1 Standard Factory, Eastern Industrial Estate, Harlow, Essex.

JOHN YUILLE (METAL WORKS) LTD., have now registered their tool-room products under the trade mark "URSUS." They also announce that a further extension has been completed at their factory at the Scottish Industrial Estate, Hillington, Glasgow, S.W.2.

The Canadian Government has sold to the ENGLISH ELECTRIC CO. LTD., Marconi House, Strand, London, W.C.2, the Scarborough factory, near Toronto, comprising 14 acres of land and buildings having a floor area of 180,000 sq. ft. The factory, which was originally built in 1952 by the JOHN INGLIS CO. LTD. for the Department of Defence and has since then been run by them for the Crown, will continue to be operated by the John Inglis Co. and the English Electric Co. for the Royal Canadian Navy escort-vessel programme. When the naval programme is completed the factory will be used for the manufacture of heavy mechanical and electrical equipment. A controlling interest in the John Inglis Co. and its subsidiary company the ENGLISH ELECTRIC CO. OF CANADA LTD., was bought by the English Electric Co. Ltd. in 1950.

BESSON AND ROBINSON LTD., manufacturers of "B. et R" relays have now left their factory at Kidbrooke, London, S.E.3, and moved completely to a new 25,000 sq. ft. factory on the East Industrial Estate, Harlow, Essex. (Telephone: Harlow 25231-4.)

B. ATTEWELL & SONS, LTD., hitherto of Southall, Middlesex, moved, as from Monday, April 18, to their new factory, the address of which is Reflection Works, Thorney-lane North, Iver, Buckinghamshire. (Telephone: Iver 1102-3; telegrams: Reflection Iver.)

RENOLD CHAINS LTD., Renold House, Wythenshawe, Manchester, have acquired the whole of the share capital of the ANCHOR CHAIN CO. LTD., Oldham.

THE NATIONAL SMOKE ABATEMENT SOCIETY moved from 30 Grosvenor-place, on April 20 and its address is now Palace Chambers, Bridge-street, London, S.W.1. (Telephone: TRAfalgar 6838–9.)

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CONTRACTS

Training Aircraft. A contract has been signed by the DE HAVILLAND AIRCRAFT and ENGINE COMPANIES and the Egyptian Government for the supply of Vampire training aircraft to the Egyptian Air Force. Deliveries will take place during the summer of the present year.

Mine Winding Equipment. An order for an automatic electric winding equipment has been received by the GENERAL ELECTRIC CO. LTD., from its Australian associate company, the BRITISH GENERAL ELECTRIC CO. (PTY.) LTD. The equipment is for Mount Isa Mines Ltd. and will be installed in their Queensland mine. It will be of the double-drum type having drums 16 ft. in diameter and will be driven through reduction gears by two 2,250-h.p. direct-current motors. The equipment is designed for a final duty of raising 12 tons of ore per wind by skips, from a depth of 4,000 ft., giving an output of 350 tons per hour. Automatic push-button control from 12 different levels will be provided.

Heavy-Media Separation Plant. The FRASER AND CHALMERS ENGINEERING WORKS of the GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, have received an order from the Silvermines Lead and Zinc Co. Ltd., of Eire, to supply a heavy-media separation plant. This equipment is intended to double the tonnage of lead/barytes ore to be treated without the need for further extension of the existing flotation plant. A 7-ft. diameter separating cone will be employed, using ferro-silicon medium.

Air Liners. Trans-Canada Air Lines, have ordered three further Viscount air liners from VICKERS-ARMSTRONGS LTD., Vickers House, Broadway, Westminster, London, S.W.1. This brings the total of the Viscounts ordered by this Air Line to 25. The three extra aircraft, the value of which, with spares, will be just over £1 million, like the other Viscounts ordered, will be of type 724, and will be fitted with ROLLS-ROYCE Dart 506 propeller-turbine engines. Delivery will be early in 1957.

Obituary

PROFESSOR EINSTEIN

We regret to record the death of Professor Albert Einstein, which occurred at Princeton, New Jersey, U.S.A., on April 18, at the age of 76. A memoir will be published in next week's issue of ENGINEERING.

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MR. J. E. LEA

Inventor of Water Recorder and Coal Meter

It is with regret that we note the death of Mr. James Edward Lea, Wh.Ex., B.Sc., M.I.Mech.E., which occurred at Southport, Lancashire, on April 3, in his 87th year. He was the inventor of the water recorder and coal meter which bear his name, and the founder and chairman of the Lea Recorder Company, Limited, Recorder House, Cornbrook Park-road, Manchester, 15. Mr. Lea was born at Sandbach, Cheshire, on August 13, 1868. He was educated at Sandbach Grammar School and at Parkhurst College, Buxton, and from 1883 until 1889 served an apprenticeship with Edwin Foden, Sons and Company, Limited, engine builders, Sandbach. On completing his apprenticeship he worked for a short time at Tangyes, Limited, Birmingham, and at Laird's Shipyard, Birkenhead. In 1891 Mr. Lea entered Owens College, Manchester, and in the following year gained a Whitworth Exhibition. After obtaining a B.Sc. degree in engineering in 1894, he went to Glasgow for some electrical experience and sailed for South Africa in 1895 where he took charge of the drawing office of a mining company in Johannesburg for three years. In 1899 Mr. Lea joined the Natal Ambulance Corps, but was invalided out a year later and returned to England. In 1902, however, he was back in Johannesburg and took up work with the East Rand Mines. It was here that he began to make use of a V-notch for the purpose of measuring water and later he gradually perfected his first automatic recorder, for which he took out patents in the more important countries of the world in 1905.

In that year Mr. Lea returned home to take up the manufacture of the recorder in England. Although it excited considerable interest at various exhibitions it was several years before orders were received in considerable numbers. In 1913 the Lea Recorder Company was registered as a limited company and throughout its subsequent development and growth, Mr. Lea took a leading part. The coal meter was introduced in 1918 and, gradually, recorders for use in waterworks, sewage-disposal works, rivers and streams and for measuring all kinds of effluent were developed. Although, during recent years, Mr. Lea had not been able to take an active part in the company's business, he maintained a close interest in all its affairs to the end of his life.

He was elected a member of the Institution of Mechanical Engineers in 1906.

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We regret also to record the deaths of:

MAJOR FRANK BERNARD HALFORD, C.B.E., F.R.Ae.S., on April 16, at the age of 61. Major Halford was chairman and technical director of the de Havilland Engine Co., Ltd., and director of the de Havilland Aircraft Co., Ltd. He served as President of the Royal Aeronautical Society for the session 1951–52.

MR. ABRAHAM ELIA MARGOLIS, Dipl. Ing., at his home at 45, Branham-gardens, London, S.W.5, on April 13. Mr. Margolis, who was in his late seventies, was a specialist on district heating and, since December, 1941, had been with the firm of Kennedy and Donkin, consulting engineers, 12 Caxton-street, London, S.W.1. Prior to this, Mr. Margolis had been responsible for district-heating schemes in Hamburg and elsewhere in Germany. He was a contributor to ENGINEERING and, in 1953, gave a paper to the British Association, entitled "District Heating," which we published in our issues of October 2, 9 and 16 of that year.

CABLE RATINGS AND SOIL THERMAL RESISTIVITIES

Essential to take Measurements

We reproduce below a statement which has been issued with the authority of all the British cable manufacturers who are engaged in the production of impregnated-paper insulated and varnished-cambric insulated cables for any voltage.

The statement records their view that measurements of the thermal resistivity of the core should be an essential preliminary to the determination of the correct current rating for a given cable. The statement reads:

The forthcoming publication by the British Electrical and Allied Industries Research Association of a new booklet (reference F/T 183) entitled—" Current Ratings for Paper Insulated Cables to B.S. 480 : 1954, and Varnished Cambric Insulated Cables to B.S. 608 : 1955," contains two tabulated sets of ratings for cables laid direct in the ground (and for cables in underground ducts). These ratings are based on two alternative values for soil resistivity, namely, $g = 120$ and $g = 90$.*

This is a departure from past practice because in the earlier ratings published by the Research Association (reference F/T 128) all ratings for cables laid direct in ground or in ducts were tabulated for one value only of soil resistivity, namely, $g = 120$. It was possible however, to obtain the rating for any other value of g from a curve of correction factors which was given in the same booklet.

TABULATION OF g

In the new publication these correction factors are still included, but instead of giving them in the form of a curve, actual factors are tabulated for fixed values of g, namely: 60, 150, 180, 210, 240, 270 and 300 with the advice that in order to take account of irregularities in soil conditions along the route the current rating or rating factor appropriate to the value next *above* the maximum measured value should be used. Soil thermal resistivity measurements should therefore be an essential preliminary to the determination of the correct current rating for a given cable; and it is hoped that one effect of this new publication will be to encourage users to determine soil resistivities along their cable routes in order that the correct current rating can be applied. The situation, however, must be faced where such figures for soil resistivity are not available or are not readily obtainable.

Hitherto the practice has been to assume a soil resistivity of $g = 120$ and the result has been eminently satisfactory. The publication of tabulated ratings for a lower value of g in no way affects the position and the cable industry of this country will continue to base their current ratings on $g = 120$ in all cases where a more precise figure is not available. In thus continuing a long established practice, the industry is not being unduly conservative or pessimistic because there is very good reason to believe that in many instances soil conditions in this country fall within the range 90 to 120 and, as already stated, to take account of irregularities along the route, the cable rating should relate to the highest value and not the lowest or the average.

MAXIMUM TEMPERATURE

Nowadays there is an increasing tendency to operate cables at or near their maximum limit of temperature by, for example, taking proper cognizance of the actual shape of the load curve and applying peak ratings which are substantially in excess of the tabulated continuous ratings. This practice, correctly applied, is safe because it does not involve the maximum safe temperature of the cable being exceeded. Furthermore, the maximum operating temperature of all cables for working voltages up to and including 6·6 kV have already been increased by 10 deg. C. and the current ratings increased accordingly.

In view of the above the actual value of the thermal resistivity of the soil becomes more important. The procedure therefore which the cable manufacturing industry recommends as soon as the new ratings are published may thus be summarised:—Wherever possible actual measurement of soil resistivity should be taken at suitable intervals along the route or otherwise the probable maximum soil resistivity should be assessed from the information given about different soils in the new publication.

When neither course is practicable the cable rating should be that corresponding to $g = 120$.

* The thermal resistivity g of a material is the temperature difference in deg. C between opposite faces of a centimetre cube of the material to produce a flow of heat of 1 watt and is expressed as so many "thermal ohm cm." or "deg. C. cm. per watt."

* * *

SEPARATION PLANT FOR TOWN REFUSE

Income Derived from Salvage

An interesting and, from the point of view of the treatment and disposal of town refuse, probably novel, separation plant has been installed at Worthing. It was described by Mr. J. Wilkinson, A.M.I.C.E., and Mr. G. A. Frake, A.M.I.C.E., in a paper presented at the Worthing meeting of the Royal Sanitary Institute on March 30. The choice of the type of plant was naturally determined by local conditions but the income received for salvaged materials and the reduction in the area of land required for the disposal of waste should make the system attractive for wider application. The collection and disposal of town refuse are expensive activities and no type of plant is likely to turn them into profitable undertakings, but as the Worthing plant is showing a return of £20,959 for salvaged materials it should be worthy of study, if not copying, by authorities now indulging in uncontrolled tipping.

The plant is situated adjacent to the sewage works and to low-lying ground available for tipping, but as it was considered desirable to economise in the use of this land, measures to reduce the amount of material to be tipped were considered. Incineration was rejected on the grounds of expense and because there is little use for incinerator residue. Separation and pulverisation were also not attractive as pulverisation as a preliminary to tipping appeared unnecessary, and experience by neighbouring authorities showed that there was little demand for the pulverised material as a soil conditioner. On these grounds, separation and controlled tipping were adopted, the recovered dust providing ample cover for the tip, and separation, besides providing some income, reducing the amount of refuse to be tipped.

The total cost of the installation including a weighbridge, roads and offices, was £57,250. The refuse handling and treatment plant was supplied by Messrs. Heenan and Froude, of Worcester. It can deal with 85 tons of crude refuse per eight-hour day. The average intake is 18,000 tons per year, of which 1,100 tons are pre-separated salvage, mainly paper and metals. The refuse vehicles tip into a main hopper of 80 cub. yd. capacity, the trailers containing pre-separated salvage tipping into a separate hopper. The refuse is carried from the main hopper by a steel-plate conveyer which discharges to an elevating belt conveyer which discharges the material into an 18-ft.-long rotary screen. Unbroken bottles and jars are removed at the lower end of the elevating conveyer. The rotary screen is divided into two sections and deposits dust and cinders into separate hoppers. From the screen, the refuse passes to a picking belt at the front end of which there is a magnetic separator which removes ferrous-metal articles which pass to a bailer. From the picking belt, which travels at 50 ft. per minute, paper, rags, non-ferrous metals and cullet and bones are removed separately. The remainder of the refuse is discharged from the picking belt to a conveyer which carries it to a tailings hopper, whence it is removed to the tip.

The uncleaned cinders, removed by the rotary screen, were found to have a thermal value of only 3,300 B.Th.U. and they clogged the fire-bars in tests on normal boilers and nursery boilers with forced draught. When cleaned, the B.Th.U. value was increased to 6,500, but the material is only satisfactory when mixed in the proportion of 2 to 1 with coke breeze. The fine dust, as already mentioned, is employed for covering the tip. About 1,000 tons of pre-separated paper are sold each year, and it is hoped to increase this figure by 440 tons with material recovered from the picking belt. Recovered paper is the main source of income from the plant but imposes serious budgeting difficulties. The price received per ton over the last four years has varied from £16 to £6 10s. No difficulty has been found in disposing of rags of any kind and may bring in some £2,700 per year. Although the market for bottles, jars and cullet is restricted, all recovered has so far been sold; the average price for bottles and jars is £2 10s. per ton and for cullet £1 10s. per ton. Tins, which are baled, bring in £2,116 per year, ferrous metals £805 and non-ferrous metals £600.

The total personnel employed on the salvage plant is 16, of whom three are pickers and six bailers. The total annual cost is £59,464. To set against this there is a gross income of £21,326, giving a net cost of £38,138. This represents a net cost per 1,000 population of £545.

The authors of the paper are members of the staff of Mr. G. H. Kempton, the Borough Engineer, under whose direction the plant has been installed. The original suggestion for a separation plant was made by Mr. P. E. Harvey, O.B.E., the former borough engineer.

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BROKEN SCAR PUMPING STATIONS

Complete Electrical Equipment

The new pumping plant and rapid gravity filtration works of the Tees Valley Water Board at Broken Scar, about four miles west of Darlington, were officially inaugurated on Wednesday, March 30. They are to supply purified water to the whole of the Tees Valley area with the exception of Darlington itself and embody two separate pumping stations. One of these stations delivers up to 12 million gallons of water a day from the river to a reservoir. The water then flows by gravity through filters into the sump of a second high-lift station, whence it is transmitted to the Long Newton reservoir about 10 miles away.

The low-lift station is equipped with six pumps which were constructed by Gwynnes Pumps, Limited, Lincoln. These pumps are driven by 3·3-kV vertical squirrel-cage induction motors supplied by Metropolitan Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, two of which have an output of 220 h.p., two of 185 h.p. and two of 135 h.p. at a speed of 735 r.p.m. One of each pair acts as a stand-by to the other.

The equipment in the high-lift station consists of two 840-h.p. and two 525-h.p. pumps which are driven at a speed of 980 r.p.m. by 3·3-kV horizontal slipring motors. The speed of the smaller motors can be varied from 980 to 800 r.p.m. by liquid rotor regulators.

Power is obtained from the public system through 6·4-kV duplicate feeders and is stepped down to 3·3 kV in two 1,500-kVA transformers. The secondaries of these transformers are connected to the pump motors in both of the stations through duplicate feeders. At the low-lift station a supply for lighting and auxiliary services is obtained at 415 volts from two 50-kVA transformers, while two 200-kVA transformers are provided in the high-lift station for the same purposes.

ITALY'S STATE-CONTROLLED INDUSTRIES

TAXPAYERS MEET LOSSES OF ENGINEERING FIRMS

By Richard Bailey

The industrial history of Italy has been profoundly affected by political events. The division of the country into numerous petty states up to the unification of 1864 lead to piecemeal development. There was no national railway system, for example, before 1890. The unification led to the abolition of internal customs barriers and the introduction of national policies for finance and trade. These national policies helped industry to grow in the north but ruined the industries of the south, which had hitherto enjoyed the protection of a high tariff wall. The movement of the terms of trade against agriculture in the last quarter of the Nineteenth Century dealt the south a further blow. A considerably higher birth-rate, a general poverty of natural resources and a resistance to any change of ideas have all combined to make southern Italy a depressed and backward region, where emigration has always been regarded as the only cure for economic and social problems.

The present structure of Italian industry is a legacy of Mussolini. From the time of unification one considerable weakness of the Italian economy was the lack of flexibility in the banking system. Reserves were on the whole inadequate and deposits were used for loans for long-term investments. The great expansion of industry during and after the first World War led to a greatly increased demand for credit. The banks were unable to meet the demand and numerous failures took place. In 1931 a credit corporation called I.M.I. (Istituto Mobiliare Italiano) was set up to provide medium-term loans for industry. This was the heyday of Fascism. Grandiose schemes were put in hand, of which the most famous were perhaps the draining of the Pontine Marshes and the so-called battle for wheat. (One Fascist engineering scheme, the Roman underground railway, was only finished a few months ago.)

In 1933 it was clear that a further attempt at strengthening the financial structure of Italian industry was inevitable. This took the form of the creation of the Institute for the Reconstruction of Industry (I.R.I.) which to-day, after 22 years of existence, plays a very considerable part in the economic life of Italy. I.R.I. was originally intended as a credit institution for giving long-term loans to industry and freeing the banks for commercial rather than industrial purposes. I.R.I. has developed, however, as the intermediary between private capital and industry. In 1937 it was put in charge of the various properties which at one time or another have been taken over by the State. As a result, I.R.I. to-day controls a mixed bag of enterprises spread over five groups of industries, which together form an important part of the Italian economy. The basis of the influence of I.R.I. is control of credit through its holdings in the three banks—Banco di Roma, Credito Italiano and Banco Commerciale Italiana. The investment policies of these banks are controlled by I.R.I. and form a very useful support for the monetary and financial policies of the Italian Government.

The fortunes of the I.R.I.-controlled industries are best considered in turn. Finsider, the Steel Finance Company, was formed in 1937 and now controls among others the Terni, Ilva, Siac and Dalmine companies. It controls 44 per cent. of all steel production and 66 per cent. of pig iron production. It is in many ways the most important part of the I.R.I. empire. At the end of 1953 production of Finsider plants had reached 1,566,000 tons of raw steel and 832,000 tons of pig iron. Finsider's three biggest plants are at Piombino, Bagnoli and the famous Cornigliano—the Margam of Italy.

The next most important I.R.I. group is Finmeccanica (Mechanical Engineering Finance Company). This concern, which was only formed in 1947, employs about 13 per cent. of labour in Italian mechanical engineering. Its products range over shipbuilding (80 per cent. of Italian total), ball bearings (40 per cent.), radio and telephone equipment (30 per cent.), buses (25 per cent.), precision instruments (20 per cent.), and tractors (20 per cent.). The firms involved include Alfa Romeo and Ansaldo but not Fiat, which is entirely outside I.R.I.

The third big I.R.I. group is Finelettrica (National Electric Finance Company). This is a comparative newcomer, formed in 1952, which now controls about a quarter of the total Italian production of electricity. A number of new generating plants are under construction with a total capacity of 800 MW.

Finmare (Maritime Finance Company) has encountered many difficulties since it was set up in 1936. At the present time it controls only some 18 per cent. of Italian merchant tonnage. In 1938 the group's tonnage was more than twice as great, but war damage has not been easy to replace. A number of Liberty ships were bought after the war but on the whole the Finmare fleet is out of date. The main companies in the group are Italia, Lloyd Triestino and Adriatica.

The fifth constituent of I.R.I. is S.T.E.T. (Telephone Company of Turin) which now owns some 61 per cent. of all installed telephones through the control of three of the principal national telephone companies. In addition, I.R.I. has one or two other holdings that fall outside the scope of the five main groups. Of these the most important is probably R.A.I., the Italian radio and television network.

This hard core of state-controlled industries has a profound effect on the Italian economy. In 1953 the I.R.I. concerns lost 20 billion lire, in 1952 the loss was 2 billion lire higher. I.R.I. is not an alternative form of nationalisation. There is no positive policy for extending the holdings of any of the groups. It is a phenomenon which has come about largely by chance. The late political development of Italy held back economic development, and in particular the growth of an adequate banking system. When the great upheaval of the first World War came, the Italian economic system was unable to withstand its shock and exceptional measures had to be taken. What started as shock treatment has become the nation's daily food. Neither business nor organised labour care greatly for I.R.I., but the changes that would have to be made, particularly in the size of the labour force, to make it into a going concern are too radical for any political party or trade union to contemplate.

So Italy to-day has this highly characteristic block of state-sponsored industries controlling some 25 per cent. of the national economy. Few of the internationally famous Italian firms are involved. The concentration in iron and steel, shipbuilding and mechanical engineering puts a large slice of basic Italian industry into a sheltered sector, with the taxpayer, including, of course, all non-I.R.I. firms, to meet all losses.

For a country which needs to export manufactured goods to buy raw materials, a high level of productivity is important. To some extent, through its investment programmes, I.R.I. makes a substantial contribution here. But the existence of considerable under-employment (which incidentally is enforced by law on all firms) and the out-of-date methods followed in many industries, make it difficult for many Italian products to compete in overseas markets. Could I.R.I. be made more effective? Given the present political and social conditions in Italy, that is a difficult question to answer. Its existence is certainly a factor that must be taken into account in any assessment of the competitive strength of Italian industry.

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BRISTOL MEETING OF THE BRITISH ASSOCIATION

The preliminary programme for the annual meeting of the British Association, to be held in Bristol from August 31 to September 7, has been issued to members. The President is Professor Sir Robert Robinson, O.M., F.R.S., who will deliver his address on "Science and the Scientist," at the inaugural meeting in the evening of Wednesday, August 31. The work of the various sections will commence on the following morning and, although the programmes are not yet completed, it can be stated that the President of Section G (Engineering), Dr. S. F. Dorey, F.R.S., will deliver his address to the Section on Thursday morning, September 1. His subject will be "The Influence of the Engineer on Sea Transport and Trade". Some papers by young engineers will be taken on the same morning. On Friday morning, the subjects dealt with will be Transport: Ships and Railways, and the Engineering Aspects of Nuclear Energy. The subject of Road Transport will be discussed on Monday, September 5, and the discussion on Nuclear Energy will be continued. On the same morning there will be a joint discussion with Section C (Geology) on Geology and Engineering. On Tuesday morning, September 6, the discussion on Transport will cover aircraft and interplanetary travel, and this will conclude the programme according to the present arrangements. Professor W. F. Cassie, King's College, Newcastle-upon-Tyne, 1, is the Recorder of Section G. Copies of the preliminary programme can be obtained by those interested on application to the Secretary of the British Association, Burlington House, Piccadilly, London, W.1. The papers given to Section G (Engineering) will be published, as in previous years, in ENGINEERING.

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CHANGES AT C.I.G.R.E.

Number of Meetings and Papers to be Reduced

The March issue of *Electra*, the journal of the International Conference on Large Electric Systems (C.I.G.R.E.) announces that certain modifications are to be made in the organisation of its biennial conventions in order to lighten the programme.

Hitherto the papers presented have been divided into seventeen groups, and have all been considered during each convention. As, however, progress in some subjects is not so rapid as in others, it has been decided to divide the groups into two categories. The papers in one of these, that covering alternators, transformers, circuit-breakers, stability and extra high voltages, will, as before, be presented every two years, but those in the other will only be dealt with every four years.

For this purpose the subjects in the second category have been sub-divided into two series. The first includes cables, towers, overhead lines, insulators, relaying and direct-current; the papers on these matters will be discussed at the 1956 convention and thereafter at four-yearly intervals. The second series covers insulating oils, sub-stations, lightning and surges, teletransmission, telephonic and radio disturbances and insulation co-ordination. These will be first dealt with at the 1958 convention and then in 1962.

It is hoped in this way to reduce the number of meetings at the 1956 convention from 27 to 20, as well as to limit the number which take place simultaneously, and to cut down the number of papers, other than those presented by the Study Committees, from 111 to 75.

BOOK REVIEWS

S.B.A.C. Handbook of Recommended Basic Training Exercises. Vol. I. *The Society of British Aircraft Constructors, Limited, Technical Section, Summit House,* 1/2 *Langham-place, London, W.*1. (95*s.*)

This well-produced handbook, prepared by the Education and Training Panel of the Society of British Aircraft Constructors, deals with the craft training of probationary apprentices. It gives in outline recommendations for a common syllabus of instruction, covering the reading of drawings, the use of hand tools, measurement, marking-off, fitting, and simple machining operations. Exercises illustrative of these are dealt with most comprehensively. The exercises involve the manufacture of a wide range of pieces which not only require the use of hand and machine tools in the right sequence but provide the youth with a collection of essential tools, such as the chisel, V-block, V-block and clamp, scribing block, bench vice, calipers of various kinds, drill gauge, pliers, straight edge, square and try square, trammels, chuck key, collet, etc.

In addition, there are a series of exercises in metal plate work, involving bending allowances. These exercises cover such components as brackets, clips, cleats, stiffeners, a tray, a funnel, a pipe branch, a hinge, joints and fitting exercises of various kinds, plate assemblies, and built-up riveted components. Some of these exercises require the use of aluminium alloy; others steel. All the drawings are in third-angle projection and are very clearly arranged and dimensioned. Most of the drawings show a general tolerance of $\pm$ 0·010 in. on dimensions, but some components have dimensions with much finer tolerances, such as 0·002 in. on a dovetail $3\frac{1}{2}$ in. wide. This is a fine limit for beginners and must be difficult for them to achieve.

Exercises similar to those described in the handbook have been made use of by technical colleges for a number of years. They were fully exploited by the former junior technical schools and have been adopted, to a greater or lesser extent, by the secondary technical schools. Nevertheless, it is doubtful if such a comprehensive set of exercises is available in so convenient a form as in the handbook, which will undoubtedly prove to be of great use not only to firms in the aircraft industry but to general engineering firms. It should find a place in the library of technical secondary schools and of those technical colleges offering craft courses for young people in industry, though the high price is likely to operate against its more widespread use.

The Grinding of Steel. By ERIC N. SIMONS. *Odhams Press, Limited,* 96 *Long Acre, London, W.C.*2. (25*s.*)

It is not so many years since grinding was regarded as a process to be used only when other methods were inapplicable. The final shaping of small tools and other metal articles after hardening involved grinding, and a grindstone of some sort was always to be found in an engineering workshop. Like so many other processes in engineering, grinding has developed greatly, firstly with respect to the abrasives themselves and secondly in the design and application of grinding machines. The subject can no longer be treated as a mere auxiliary to other production methods. Consequently, there is need for up-to-date information on grinding in all its many aspects, and this book sets out to meet that need.

It is intended, the author says, " . . . as a reasonably full and practical study of its subject," and an attempt has been made to widen its application by defining technical terms as they appear in the text. Such an approach has much to commend it, but it has its difficulties and pitfalls, as the author recognises in his preface. A technical term which is familar to one reader may be unknown to another, who will welcome a definition, but the converse applies, and some readers may find it irritating to be told, for example, what a cam is, or to be informed that " refractory " means " heat resistant."

The book, as its title indicates, is mainly concerned with the grinding of steel, but mention is made of certain other materials such as cast iron, tungsten carbide and Stellite. It has been written with the co-operation of several well-known manufacturers of abrasives and grinding machines, and incorporates some useful formulæ and tabulated data. The first two chapters, which deal with the different types of abrasive, grit sizes, bonds, grades and grinding-wheel forms, are useful in view of the wide choice confronting the user to-day. From a consideration of abrasives and wheels the book proceeds to deal with the basic operations of cylindrical, internal, surface, disc and centreless grinding. Specific operations, such as the grinding of threads, rolls, cams, lathe and similar tools, broaches, scrapers and chasers, are described in separate chapters, and there are also chapters on gear-tooth grinding and the dressing of steel castings. Chapters are devoted to some of the less common operations, such as grinding small holes with diamond mandrels, and to lapping and superfinishing. Surface-finish measurement is also covered. The book concludes with chapters on finishing by abrasive belt, polishing and buffing, truing and dressing of grinding wheels, including crush-dressing, and a review of several different types of grinding machine.

There are numerous illustrations, both line and photographic, and an index with over 400 main entries. The treatment of the subject in general is, as the author intends it to be, of a practical rather than a theoretical nature. As a consequence some of the chapters are brief and simple in character. That on grinding gear teeth, for example, occupies only two pages, and does not attempt to deal with the mechanical and mathematical principles involved. As an introduction to the subject the book serves its purpose. It is likely to be of greater interest to the machine operator than to the engineer, who is concerned with much more than the actual operations on the machine.

Chemical Engineering. Vol. I: Fluid Flow, Heat Transfer and Mass Transfer. By J. M. COULSON and J. F. RICHARDSON. *Pergamon Press, Limited,* 242 *Marylebone-road, London, N.W.*1. (38*s.* 6*d.*)

Only within the last 35 years have recognised courses in chemical engineering been instituted in American and English universities, and the dearth of general texts of university level makes the present work by Dr. Coulson and Dr. Richardson both timely and welcome. This first volume is intended to cover the fundamentals of the subject and to examine the basic physical principles exemplified in one form or another, and either singly or collectively, in all industrial chemical processes.

It opens with a brief account of units and dimensions, in which no mention is made of the M.K.S. system although this is likely, before long, to supplant the more familiar C.G.S. and F.P.S. systems. The main body of the text is divided into four sections the first being devoted to the flow of fluids, with many aspects of which the chemical engineer is directly concerned. An outline of energy relationships characterising fluids in motion is followed by an investigation of the effects of friction in pipes upon streamline and turbulent flow of liquids through them, including the influence of bends and changes in section, and of the isothermal, non-isothermal and adiabatic flow of gases along horizontal pipe-lines. Laval nozzles, uniform and non uniform flow in open channels and the hydraulic jump are also dealt with. Only Newtonian fluid flow, in which the viscosity is independent of the shear, is considered, the flow of suspensions and flow through granular beds being reserved for Volume II.

Various types of manometer are described, and the theory is then given of instruments for measuring fluid flow based upon the conversion of some of the kinetic energy of the fluid into pressure energy and vice versa, such as the Pitot tube, nozzle, Venturi meter and notch. The construction and use of other devices, such as the hot-wire anemometer and quantity meters, are also explained. For transferring liquids or gases from one container to another or through long pipe-lines some form of mechanical pump is required. Various factors influence the choice of pump for a particular operation and after explaining these, pumps suitable for handling liquids are considered. Included among them are reciprocating pumps of the piston, ram and diaphragm types, rotary gear and centrifugal pumps and there is also an account of the use of compressed air for pumping and air-lift pumps. In general, pumps employed for circulating gases work on similar lines though at higher speeds, with lighter valves and smaller clearances. After describing rotary and centrifugal blowers and the two main types of vacuum pumps, the power required for compression is worked out in detail.

Section B deals with processes of heat transfer which play so prominent a part in such operations as evaporation and distillation. Typical problems in steady and variable state conduction, natural and forced convection, heat loss by radiation, heat transfer in the condensation of vapours and to boiling liquids are considered in turn.

Section C opens with an account of the diffusion of vapours in gases and of solutes in liquids, and mentions practical applications, most of which are held over for Volume II. More complex processes involving simultaneous mass, momentum and heat transfer are then studied and quantitative relations between them deduced partly from dimensional arguments and partly from an analysis of the nature of the flow near a surface. The latter is very comprehensively treated in the chapter on the boundary layer and its effect upon flow, mass and heat transfer, which also introduces the universal velocity profile and explains how it can be used for the approximate calculation of conditions close to the surface over which the fluid is flowing.

The one practical application of mass transfer considered in this volume is to humidification and water cooling, which forms the subject of the final section. Instruments for ascertaining the hygrometric state of a gas are described, together with methods for varying the proportion of water in an air-water system. The construction of water-cooling towers is then explained, and illustrated with examples of the calculation of the optimum heights for such structures.

Noteworthy features are the large collection of worked examples, the lists of references and symbols at the ends of the respective chapters, the tables of physical constants and accompanying nomograms whereby their values at various temperatures can be read off, the steam tables and the three folding charts (which can be obtained separately) exhibiting pipe-friction data and a humidity-temperature diagram for the air-water system at atmospheric pressure. This volume is excellently produced and moderately priced and if the second volume maintains the same standard of clarity and comprehensiveness the complete work will form a most valuable addition to the chemical engineer's library.

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MACHINE-TOOL MANUFACTURE

Colour Film

A 20-minute colour film has been made by Technical and Scientific Films Limited, 53 New Oxford-street, London, W.C.1, for A. A. Jones and Shipman, Limited, illustrating the production of machine tools in the Leicester works of the latter firm. The film is designed for showing to those who cannot pay a personal visit, such as overseas buyers, technical colleges and engineering societies generally. Photography and dialogue are good and the colour is very pleasing, conveying an excellent impression of modern high-precision production. Entitled "To be Precise," the 16-mm. film can be borrowed by applying to Messrs. Jones and Shipman at Narborough-road South, Leicester.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in later issues of ENGINEERING.

Non-Specialist Graduates in Industry. By ANTHEA COLLINS. *The Bow Group, 46 Queen's-grove, London, N.W.8.* (1*s.*) (Reviewed on page 460, April 15).

This Way Forward. *Sir Lindsay Parkinson and Company, Limited, 171 Shaftesbury-avenue, London, W.C.2.* (No price given.)

This Way Forward is the story of the first 75 years of Sir Lindsay Parkinson and Company, Limited, the civil-engineering and building contractors. A brief introduction traces the early beginnings of the company in Blackpool in the 1870's, noting in passing their first experience of construction in reinforced-concrete in 1905 when the Blackpool racecourse was built, and bringing the story up to 1929. From then on, the diverse activities of the company—docks and harbours, civic and industrial buildings, roads and sewers, housing and service establishments, etc.—are illustrated in pictures rather than in words. The changing methods and materials of an industry are traced in the story of the company's work both in the United Kingdom and overseas.

Practical Armature Winding. By ALFRED H. AVERY. Revised edition. *Percival Marshall and Company, Limited, 19-20 Noel-street, London, W.1.* (3*s.* 6*d.*)

This is the third edition of this little booklet designed for the amateur and the mechanic. It describes in detail the practical points involved in armature winding, and is illustrated.

Technical Reports of the British Electrical and Allied Industries Research Association. *Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.*

Flameproof Electrical Apparatus: Flange Joints, One Inch in Radial Breadth, in Mixtures of "Standard" Town's Gas and Air. By T. J. A. BROWN. No. G/T298. (7*s.* 6*d.*) One of a series of investigations designed to ascertain the effect on the maximum safe gaps, experimental and statistical, of the reduction in flange width from 1 in. to ¼ in.

Maximum Experimental Safe Gaps. A Note on the Emission of Flame through Flange Gaps. By T. J. A. BROWN. No. G/T299. (4*s.* 6*d.*) Tests to illustrate the difference between the British and American standards of flame-proofness.

On the Motion of Slow Electrons in Polar Materials. By S. ZIENAU. No. L/T299. (12*s.* 6*d.*) The technique of canonical transformation is applied to various problems and the connection with previous work by Gurari is discussed.

The Case for the Adoption of the British Plastic Yield Test as the I.E.C. Standard. By A. MORRIS THOMAS. No. L/T314. (12*s.* 6*d.*) Evidence is presented to show that the static method of yield test for solid electrical insulants as exemplified by the British test is probably to be preferred as an International Standard.

An Energy Survey in the Somaliland Protectorate. By E. W. GOLDING and A. H. STODHART. No. IB/T14. (21*s.*) Report of a survey made between April 23 and May 28, 1954, with support from UNESCO. Somaliland was chosen as being a typical under-developed semi-arid area. Potential sources of energy include wind power and solar radiation.

The Onset of Breakdown in Gases Subject to Superposed Microwave and Unidirectional Electric Fields. By W. A. PROWSE, ELIZABETH LAVERICK and W. JASINSKI. No. L/T295. (7*s.* 6*d.*) The report describes the development of apparatus and techniques required to determine the relation between breakdown stress and time of application. Results indicate that the value of breakdown stress in polyatomic gases is determined in too short a time for the diffusion theory to apply.

Electroacoustics: The Analysis of Transduction, and Its Historical Background. By FREDERICK V. HUNT. Harvard Monographs in Applied Science No. 5. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (6 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (48*s.*)

The author of this book is Rumford Professor of Physics and Gordon McKay Professor of Applied Physics at Harvard University. He is also a past-president of the Acoustical Society of America. In the book, he sets out a unified basis for the analysis of electromagnetic and electrostatic transducers, introduced by an historical survey of these devices. There is also much information on loudspeakers.

Schleusen und Hebewerke. By H. DEHNERT. *Springer-Verlag, Reichpietschufer 20, Berlin, W.35.* (45 D.M.)

A comprehensive treatise on the design, construction and operation of all types of ship locks on canals, rivers and at sea ports, with a full description of the characteristics and advantages of each type for certain conditions. It covers the history of the development of inland waterways and the means of raising and lowering ships, from 1398 to 1950, with detailed descriptions and dimensioned drawings of outstanding installations of all types throughout the world. An important section is devoted to the various systems of wet and dry, inclined and vertical, ship lifts operated by pistons, revolving drums, counterbalanced tanks and floats. The section on the construction and movement of lock gates is illustrated with details of fittings from European and American practice. Theoretical and practical considerations are discussed and comparative tables give the dimensional characteristics, filling and emptying times and other data relating to a large number of modern locks. A classified bibliography with more than 450 references to technical literature is provided as well as indexes arranged under subject matter and locality of installations.

Berichte des Deutschen Ausschusses für Stahlbau. No. 18: Versuche zur Anwendung vorgespannter Schrauben im Stahlbau, Part 1. By O. STEINHARDT and K. MÖHLER. *Stahlbau-Verlags, G.m.b.H., Cologne, Germany.* (9 D.M.)

Hitherto, bolts with tightly-fitting shanks have been used for permanent connections in steel structures. Recent tests have demonstrated the superior qualities of prestressed bolts with bolt-hole play. As the efficiency and quality of high strength bolt connections depend largely on the degree of prestressing and the ability of the bolt to retain this stress without considerable loss, extensive tests were carried out at the Technische Hochschule Karlsruhe and elsewhere on the properties of the bolt material and the stresses arising in the shank and threaded cross section due to tightening or prestressing. Micro-measurements were made on the resulting elongation of the bolt and the longitudinal stresses were determined as well as the torque between the bolt head and the nut. The tests are reported in detail including the design of the flat test bar butt joints, the effect of surface treatment by wire brushing and oxy-acetylene flash torch on the contact areas, and on the efficiency of the connection. It was found that the first application of a tensile stress resulted in a reduction of the clamping force greater than that to be expected from the transverse section of the joint material. Subsequent applications mainly resulted in elastic elongation of the bolt shank giving a grip reduction of from 2½ to 3 per cent. The work concludes with a summary of previous investigations, including the Karlsruhe tests and relevant bibliography.

La Machine-Outil. Volume II: Usinage par Tours. Prepared under the direction of A. R. MÉTRAL. *Dounod, 92 Rue Bonaparte, Paris 6.* (5,300 francs.)

A symposium of lectures given at the Conservatoire National des Arts et Métiers on the best methods of rational utilisation of different types of lathe by specialists in the respective type of machine, comprising: the study and utilisation of parallel and special lathes, of semi-automatic lathes, of automatic lathes, of multiple-tool lathes, of copying lathes, and of vertical lathes. The constructional details and operating characteristics are illustrated by numerous photographs and diagrams with examples of the cycles of machining for typical jobs. Comprehensive tables give the dimensions and characteristics of lathes by the leading European and American makers. The book is intended for both students and engineers responsible for the machine-tool equipment of large and small installations.

Einführung in die Baustatik. By ERNST CHWALLA. Second edition, improved, enlarged and reprinted. *Stahlbau-Verlags, G.m.b.H., Cologne, Germany.* (No price given.)

Notes originally prepared to assist engineers and students whose studies were interrupted by the war. They do not claim to be a carefully arranged presentation, but appear as a College note-book embracing all stages of the study of statics of loaded structures and their components, including the loading of rail and road bridges. The work has numerous bibliographical references conveniently intercalated in the text, to lectures, technical literature and advanced specialised studies. The latest scientific methods of investigation of fatigue (X-rays, supersonic vibrations, gamma processes) and the determination of safety factors are dealt with, as well as the influence of temperature on creep, relaxation and hysteresis. The book is amply illustrated with diagrams and equations, but is not intended to compete with standard text-books, nor with the contents of corresponding lecture notes issued by the Technische Hochschule.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Scaffolding and Staging. BRITISH BUILDING AND ENGINEERING APPLIANCES, LTD., 63-65 London-road, Sandy, Bedfordshire. "No-Bolt" system of sectional scaffolding for building work and for erecting staging suitable for the works maintenance and plant engineer. The main members are made from standard scaffolding tube. Connections made with simple couplers using only a driven wedge to complete fixing, no bolts, nuts or screws being required. Illustrated leaflets. (This note cancels that published under Trade Publications in the issue of January 14.)

"Modern Methods of Lubrication." TECALEMIT LTD., Plymouth, Devonshire. A comprehensive survey of methods of lubrication for all types of plant, showing how the firms' products can be used for each. The volume, in loose-leaf binder form, is divided into eleven sections, the first seven describing different systems, and the remainder covering such items as layout of pipe-work and ancillary equipment made by the firm. Supply of copies is limited and a charge of 25*s.* per copy, post free, is made.

Induction Heating. RADIO HEATERS, LTD., Eastheath-avenue, Wokingham, Berkshire. Radio-frequency induction-heating described in principle and practice in a large illustrated brochure (price 6*s.*). Details are given of the many applications to soldering, brazing, hardening, etc., as well as descriptions of generators; over 60 illustrations of different types of work. Also graphs showing running costs.

Machine Knives. SANDERSON BROTHERS & NEWBOULD LTD., P.O. Box No. 6, Newhall-road, Sheffield, 9. "Saben" knives and circular cutters for machines used in the tobacco, paper, woodworking, textile and packaging industries; also various metal-cutting blades and other products including Xylonite knives, fruit-pulping knives in stainless steel, glass bottle knives and wood wool knives. Illustrated leaflet (M.E.15.).

Woodworking Machinery. THOMAS ROBINSON & SON, LTD., Rochdale. Brief details of 14 machines in the Robinson range, including bandsaws, circular saws, planers, moulders and a mortising machine. Each machine is illustrated, and there are some details of the works at Rochdale where the machines are made. Illustrated folder.

Treating Cooling Water. ALBRIGHT AND WILSON LTD. 49 Park-lane, London, W.1. "Micromet" treatment for recirculating cooling-water systems. Micromet dissolves slowly from a dispenser which lasts for several weeks. Pamphlet gives diagrams of system and tables for calculating quantities required.

Instrument Kits. ROCKE INTERNATIONAL CORPORATION, 13 East 40th-street, New York 16, N.Y., U.S.A. Kits for making high-fidelity amplifier and television sweep generator, produced by the Heath Company. Leaflets give circuits and details.

Voltage Reference and Stabiliser Tubes. MULLARD LTD., Century House, Shaftesbury-avenue, London, W.C.2. *A Guide to the Application of Voltage Reference and Stabiliser Tubes* gives fundamentals, design applications and details of types available with performance curves.

Electrical Equipment. BRITISH CENTRAL ELECTRICAL CO. LTD., 6 and 8 Rosebery-avenue, London, E.C.1. General electrical supplies; 250-page catalogue covers items from insulating staples to automatic generating sets, and from kettles to mobile cranes. Index lists over 900 items.

Shunting Tractor. F. E. WEATHERILL LTD., Union-row, London, N.17. "Epping Auto-shunter" tractor for moving railway wagons or towing trailers. Can also be fitted for bulldozing. Fordson-Major Diesel engine. Leaflet gives particulars.

V-link Belting. H. BRAMMER & CO., LTD., Hudson-road, Leeds, 9. V-link belting of leather or synthetic rubber. Illustrated brochure and catalogue gives applications and rating tables for types and sizes available.

High-Power Klystrons. ROCKE INTERNATIONAL CORP., 13 East 40th-street, New York, N.Y., U.S.A. Various high-power klystrons for frequencies from 375 Mc/s to 10,000 Mc/s with powers up to 1 MW (pulsed). Illustrated leaflet.

Dust Collector. STURTEVANT ENGINEERING CO. LTD., Southern House, Cannon-street, London, E.C.4. "Uniclone" dust collector for lathes, grinders, etc. Illustrated leaflet.

POWER EXPORT FROM YUGOSLAVIA

DEVELOPING HYDRO-ELECTRIC RESOURCES

In October, 1951, the Committee on Electric Power of the United Nations Economic Commission for Europe, at a meeting in Geneva, discussed the political, legal and administrative difficulties connected with the transfer of electric power across national frontiers and made recommendations about the charging of import or export duties on constructional material and about other administrative matters. It also noted with satisfaction that the secretariat had initiated negotiations between Yugoslavia and Austria and Yugoslavia and Italy about the interchange of electric power. Since that time, as a result of other meetings, various reports dealing with this subject have been issued. In one, which appeared in 1952, it was stated that Italy had developed 48 per cent. of her possible water power, but Yugoslavia only 2 per cent. and Austria 17 per cent.

In a still later report, published in 1953, it was stated that the consumption of electricity on the Continent of Europe was doubling every ten years, and the construction of a power grid embracing Yugoslavia, Albania, Austria, Hungary and Greece was suggested. A facile proposal of this kind is not likely to lead to any useful end unless it is based not only on extensive technical examination of resources, but on at least some measure of agreement on administrative matters. This type of grandiose scheme certainly has both technical and economic attractions, but it does not appear that it could be agreed on, even in principle, by the countries concerned without a measure of political accord, of which there are no signs at present, particularly in the cases of Hungary and Albania.

EXPORT TO ITALY, AUSTRIA AND GERMANY

A further report,* recently published, may fairly be described as a more business-like document, as it is based on the work of a co-ordinating committee made up of experts, both technical and financial, from the various countries which are concerned in the plan put forward. Broadly, the proposal is that four new water-power schemes should be initiated in Yugoslavia, and one project now being carried out should be extended. The five plants would be linked by transmission lines which would deliver power to Italy, Austria and the Western Zone of Germany. The greater part of Yugoslavia is traversed by the Dinaric Alps which run roughly parallel to the Adriatic coast along which the five plants would be strung. They would tap and utilise a large number of rivers flowing from the mountains to the Adriatic Sea. The positions of the plants and connecting transmission lines are indicated on the accompaning map.

It is clear that these extensive proposals have not been put forward without careful examination of the issues involved. The co-ordinating committee, an inter-governmental body which called itself Yougelexport, set up four subcommittees which dealt respectively with economic, technical, financial and legal questions. Although the economics and finance of the project are closely linked they are not the same thing. The effect of the scheme, if carried out, on the economic life of the countries concerned is clearly the basic consideration to be kept in mind, but the carrying out of the scheme must depend on the possibility of raising the necessary capital. The estimated total outlay for the whole project, which it is suggested should be carried out in six stages, is 309 million U.S. dollars for the power stations and 70 million for the transmission lines in Yugoslavia, and a further 40 million dols. for construction of transmission lines in the importing countries. Some contribution could possibly be furnised by the countries concerned, but the financial committee is clearly correct in assuming that assistance from the International Bank for Reconstruction and Development, or some other United Nations agency, would be necessary.

It was stated in the 1952 report that Italy had developed 48 per cent. of her possible water power; in the present report it is said that she has already harnessed the " great part " of her resources. Whichever of these statements is accepted, it is certain that the growing demands in Italy, Austria and Western Germany will furnish a market for power from Yugoslavia, especially as maximum supplies from the projected scheme would be available in the winter. It is considered, in the case of Austria, that import of supply from Yugoslavia in the winter could be balanced by supply to that country in the summer. The calculated total potential export of power from Yugoslavia to the three countries concerned could be 400 million kWh in 1956, rising to 4,300 million kWh in 1970 and the important part which Yugoslavia might play in winter supply is indicated by the estimate that while the summer export in 1970 would be 640 million kWh, the winter export would be 3,660 million. An average price per unit, put forward only with caution, is 1·2 U.S. cents.

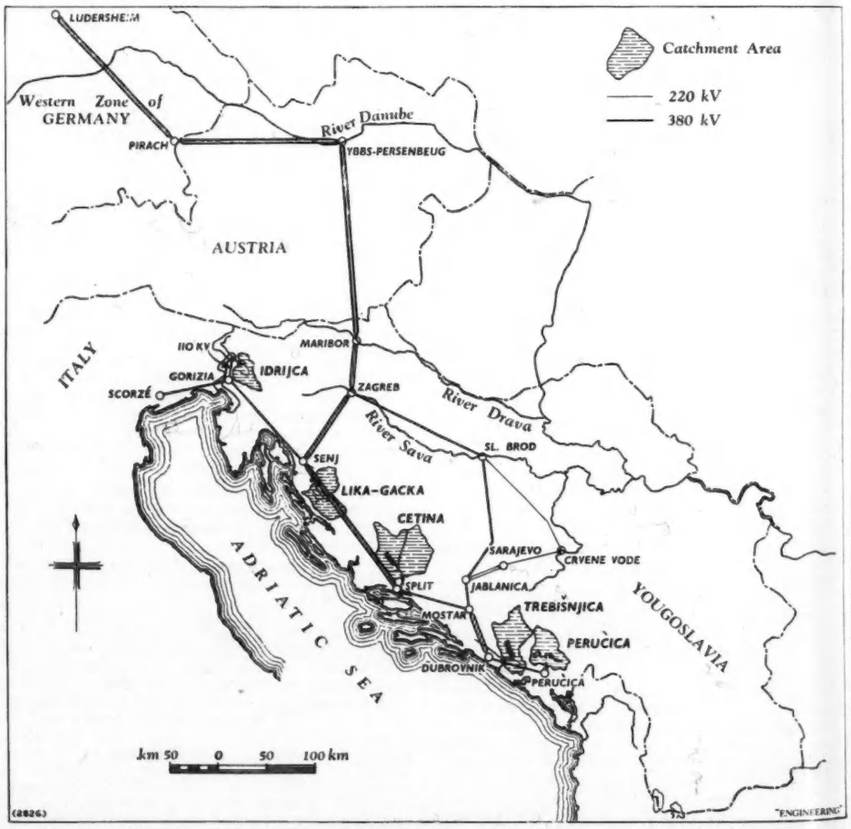
INTER-GOVERNMENTAL COMMITTEE

The legal aspects of the Scheme will involve political considerations which it may be hoped will not mar its technical attractions. The report suggests that an inter-governmental co-ordinating committee, consisting of two representatives from each of the four countries concerned, should be set up. The present Yougelexport is an inter-governmental body but it is made up of engineers and financial experts. Presumably the suggested co-ordinating committee would be of a more political complexion and with more political influence.

The technical members of Yougelexport have evidently given great attention to the engineering arrangements of the suggested installations; these have been worked out in considerable detail. The Perućica station which is now under construction, but which it is suggested should be extended, taps the waters of the River Zeta. Four reservoirs are to be constructed to regulate tributaries of this river and it is proposed that ultimately power stations shall be built below the dams forming three of these reservoirs. The main station at Perućica through which the discharge from the other stations will pass is expected to have an installed capacity of 94 MW in 1957 and 171 MW in 1958. The Perućica station will work under a gross head of 547 metres. The catchment area, the extent and position of which is shown in the map, covers about 850 sq. kilometres. The total cost of the plan is estimated at 35,838,000 U.S. dollars, of which 10,177,000 dollars will be for hydraulic, electrical, and mechanical equipment. Most of the proposed tributary dams are to be of the clay-core type with masonry facing.

UNDERGROUND POWER STATION

The second plant to come into operation is that at Cetina, which is listed as delivering power in 1961, and has a capacity of 530 MW. The name Cetina is derived from the river which it is proposed to harness. The power station, which is to be of the underground type, would be situated at the well-known port of Split. It would operate under a head of 288 m. and would be equipped with four 178,000-h.p. sets. The river has a catchment area of 4,300 sq. km. It is proposed that a smaller station should be built below the dam forming a reservoir at Peruca. The geological formation is in general limestone and grouting would probably be necessary at the dams. The total cost of the Cetina project is estimated at 94 million dols.



A plan for using the water-power potential of Yugoslavia includes the building or enlarging of five power stations and the export of electricity to Germany, Italy and Austria by the proposed transmission lines shown.

* *Prospects of Exporting Electric Power from Yugoslavia.* Economic Commission for Europe, Palais des Nations, Geneva, Switzerland. (3*s.* 6*d.* 2 *Swiss francs.*)

The Lika-Gacke project covers the harnessing of two rivers of these names with a total catchment area of 1,740 sq. km. The geological formation is of difficult type for constructional work and both rivers disappear into swallow-holes before reaching the sea. The power station, of underground type, and containing four 91,500-h.p. sets working under a head of 432 m., would be situated at Senj on the coast. The total cost is estimated at 42 million dols. It is considered that power should be available in 1963.

The Idrijca project, which is scheduled to go into operation in 1965, would utilise the waters of the Idrijca River and its two main tributaries. The constructional work would evidently be extensive as 77 per cent. of the cost is set down against civil engineering. The underground power station situated at Doblar, north of Gorizia, would contain three 46,900-h.p. units working under a head of 174 m. The cost per kW of installed capacity for this station is estimated at 410 U.S. dollars which is more than twice as much as that for any of the other new projects.

The most important scheme from the point of view of power output is that which utilises the waters of the Trebišnjica River which rises in the southern part of the Dinaric Alps. The power station at Dubrovnik would contain six 152,000-h.p. sets, working under a head of 289 m. This project is the last to be scheduled for completion, the estimated date being in 1966. The Technical Committee of Yougelexport recommended that a thorough geological survey be made of the ground on the sites of the reservoir and dam of the Trebišnjica project before a decision is made whether to proceed with these works. This probably accounts for its relegation to the lowest position in the order of construction. The cost per kW of installed capacity at 138 U.S. dollars is the lowest for any of the schemes. Civil work is estimated at 61·7 per cent. of the total cost.

Institution of Naval Architects Spring Meeting (*continued from page* 482)

RESISTANCE EXPERIMENTS ON THE "LUCY ASHTON"

In addition to the Amos Ayre Lecture on April 4, the 1955 Spring Meeting of the Institution of Naval Architects consisted of five technical sessions, at which seven other papers were presented. These were, on the morning of April 5, Part IV of "The B.S.R.A. Resistance Experiments on the 'Lucy Ashton'," by Dr. S. Livingston Smith, C.B.E., and "Recent Developments in Naval Life-Saving Equipment," by Mr. W. J. Holt, R.C.N.C.; in the afternoon of the same day, "A Hundred Years of Lloyd's Register Ship Rules," by Mr. J. M. Murray, M.B.E., B.Sc., and "Forty Years of Change at Portsmouth Dockyard," by Mr. Ivor E. King, C.B.E., R.C.N.C.; and, in the evening, at a meeting held jointly with the Institute of Marine Engineers, "Sea Trials on a 9,500 Tons Deadweight Motor Cargo Liner," by Professor G. Aertssen. The first part of the morning session on Wednesday, April 6, was devoted to the annual general meeting and the President's address, which were followed by a paper on "Liners of the Past, Present and Future on Service East of Suez," by Sir William C. Currie, G.B.E., chairman of the Peninsular and Oriental Steam Navigation Company, Limited. In the afternoon, Mr. L. T. Carter, B.Sc., R.C.N.C., and Mr. J. T. Crennell, M.A., presented the concluding paper, on "The Cathodic Protection of Ships Against Sea-Water Corrosion." In the evening of April 6, the annual dinner was held in the Connaught Rooms, when the Institution was honoured by the presence of His Royal Highness the Duke of Edinburgh, K.G., to whom the President presented the Diploma of Honorary Membership.

EFFECT OF FOULING

Mr. R. B. Shepheard, C.B.E., B.Sc. (Chairman of the Council) took the chair at the first technical session, when Dr. S. Livingston Smith, Director of Research of the British Shipbuilding Research Association, presented the fourth and last part of "The B.S.R.A. Resistance Experiments on the Lucy Ashton," dealing with "Miscellaneous Investigations and General Appraisal." The paper was accompanied by a film showing the vessel on her preliminary trials on the Clyde; trials undertaken to ensure that the quartermaster in charge could satisfactorily control the ship under the novel conditions of propulsion by four Rolls-Royce "Derwent" jet engines, and that the investigators, in their sound-proof cabin, could take the necessary measurements of thrust, etc., from the instrument dials assembled there. The provision of the sound-proof cabin was essential because of the noise of the four engines. In it were the quartermaster, two engineers, and the observers.

The investigations described in the paper included the effects of fouling on resistance, corresponding to various periods of immersion at different times of the year; acceleration and retardation trials, from which the virtual mass of the ship was determined; and Pitot-tube traverses in the ship's frictional belt, giving velocity distributions for various hull-surface conditions. The rapid increase of fouling while the vessel was lying in the Gareloch between trials was a feature of particular interest. She had been docked for inspection in April, 1951, and was refloated on April 7. On May 1—only 24 days later—it was found that the resistance at 12 knots had increased by 7½ per cent., as compared with the clean-ship runs made only a month before. On May 7, therefore, further runs were made, by which time the increase in resistance had risen to almost twice that measured six days earlier—about 14 per cent. at 12 knots—showing that the bottom was either fouling or deteriorating at a rapidly-increasing rate. On June 4, several more runs were made, prior to docking, to ascertain whether the fouling had progressed farther, and the resistance at 12 knots was found to be 30 per cent. higher than in the clean-ship condition. Those tests on June 4 were the last carried out on the vessel, which was broken up shortly afterwards. It was pointed out that the fouling took place on a surface of bituminous aluminium paint, which had no special anti-fouling properties. There was a band of fine grass-like weed along the length of the ship, extending some 3 ft. to 4 ft. down from the waterline and, at the waterline, a band, 6 in. wide, of a longer and darker growth. Below the grass there was no vegetable growth, but there were small white conical barnacles, distributed at about 30 to 35 per square foot.

In his review of the principal findings from the Lucy Ashton investigations, Dr. Livingston Smith stated that the trials carried out in the clean-hull condition had proved the sensitivity of full-scale ship resistance to small roughnesses. In particular, it had been shown that fairing the seams reduced the total resistance by about 3 per cent., and painting the hull with the smoother bituminous aluminium paint instead of red oxide had reduced it by a further 3 per cent. Runs made with a ½-in. trip-wire (comparable in size, to scale, with the trip-wire used on the 12-ft. model) showed that the percentage effect on the full-scale resistance was of much the same order as the 1 to 2 per cent. measured on the model. The added virtual mass of the ship, determined from the acceleration and retardation trials, had been correlated with the results of previous work to give, for the first time, a curve of added virtual-mass coefficients covering a wide range of ship forms and streamlined bodies. Frictional resistance coefficients for the ship had been deduced from velocity distributions measured in the ship's boundary layer in both the clean and the fouled conditions; they were of the same order as the corresponding values determined from the ship-model correlation of resistance measurements, and confirmed the experimental results.

SKIN-FRICTION FORMULATIONS

The ship results were correlated with the results of tests made in the No. 1 Tank at the National Physical Laboratory on a series of geometrically similar models ranging in length from 9 ft. to 30 ft., using the usual Froude frictional coefficients and also some of the modern skin-friction formulations. Though the investigation did not show conclusively which of these was the best for predicting ship resistance from model tests, it did enable the performance of the various methods to be accurately assessed for a ship in the 200-ft. length category and for a wide range of model lengths. The alignment of the cross curves of constant Froude number on the extrapolation diagrams suggested that, as far as concerned that family of geometrically similar models, Froude's law of comparison had been vindicated as regards the scaling-up of wave-making resistance in the usual manner; and that statement could be extended to include the measured ship resistance, subject to the acceptance of the roughness allowances, which depended on the particular skin-friction formulation used. Current practices in the assessment of shaft-appendage resistance were also generally confirmed, subject to the reservation that, in the Lucy Ashton, the bossing webs were inclined across the flow. Dr. Livingston Smith concluded his review with some indications of possible future lines of inquiry, based on the information acquired during the tests with the Lucy Ashton.

NEED FOR RELIABLE RESISTANCE DATA

Dr. R. W. L. Gawn, O.B.E., who opened the discussion, said that the paper, which concluded "a wonderful series," showed the real extent of the debt that naval architects owed to the British Shipbuilding Research Association for their enterprise and effort. The famous report of the British Association, presented in 1869, emphasised the need for reliable resistance experiments on ships with all relevant measurements and precautions. Despite the lapse of time since then, very few trials had been carried out. Thanks to the author and those associated with him, the need had been reliably satisfied for one ship, at all events, over a wide field. The key to reliability was the ingenious conception of jet propulsion. Probably the most valuable of the many results was the substantial vindication of Froude's law for residuary resistance, and of the method of predicting the resistance of shaft appendages from model tests. The attractive improvement effected by attention to surface finish should stimulate further developments in that respect. True, no skin friction formulation had been found to be completely satisfactory throughout the speed range for all sizes of model, but that merely showed the complexity of the problem, and that the complications were even deeper than was formerly supposed. One other point emerged, namely, the wisdom of consistency in size of model and procedure for predictions generally. The extension of the investigation to larger ships, which the author envisaged, was one most commendable step in that direction. In his view, developments in naval architecture had reached the stage when they "could no longer afford not to afford" the large expense involved.

The paper indicated a marked increase of resistance due to fouling, but that was not surprising, as the ship was stationary between trials and no precautions were taken to limit marine growth. The lower rates of increase quoted from Admiralty experience were con-

firmed. One recent trial with a large ship, 3½ months out of dock, indicated a daily average increase of skin friction resistance of only one-twelfth of 1 per cent. According to Professor Aertssen's paper to be given later during the meeting, concerning the single-screw cargo ship, a commensurate value seemed to be obtained for that ship when six months out of dock. The Lucy Ashton trials covered only a bare two months, but, even so, the rate of increase of skin friction fell off in the final weeks and was then fairly linear and ultimately about a quarter of 1 per cent. per day.

The paper would be most helpful in dealing with manœuvring and surging problems. In practice, starting and stopping were controlled by the propellers, and reliable deductions as to virtual mass were precluded. A stopping trial, however, was carried out on a destroyer a few years ago with the propellers locked and a virtual mass coefficient of 15 per cent. was deduced. The length constant of the ship was 8·29, so the spot was above the author's curves, though below some of the spots at smaller length constant. The difference seemed rather larger than could be attributed to the difficulties of deducing the coefficient. The large resistance of the propellers might be a factor, but speed and other parameters might be involved, though perhaps to a less extent than length constant. The paper showed that the Pitot traverses had given valuable information, and he suggested that, in any further trials which might be made on naked ships, attention should be paid to Pitot traverses at the stern.

FOULING UNDER NORMAL OPERATING CONDITIONS

Professor G. Aertssen noted that, concerning the effect of fouling on resistance, the author had given some very high figures for the increase of resistance per day out of dock, and related them to figures given by old and recent Admiralty experience. The high figures obtained after 24 days out of dock (2 and 1 per cent. increase in skin friction) would certainly have been much lower had the ship been in service. The Lucy Ashton experiments had been conducted with the utmost care, but he felt that the results on the effect of fouling could not be extended to commercial ships, because the Lucy Ashton was not operating under normal commercial conditions. It was certainly useful to have separate figures for temperate and warm waters, but more than that was involved; there was the speed of the ship and, above all, the ratio of the time in harbour to the time at sea. The Victory ship "Tervaete" came out of dock, sailed to India and East Africa, where she spent a long time in harbour, and returned to Antwerp after three months with an increase of resistance of more than 20 per cent. After that she was engaged in the service Antwerp-New York-Congo-New York-Antwerp, but showed no more appreciable increase of resistance up to the time she was dry-docked a year later. The M.V. "Lubumbashi," of 15 knots, sailed on the service Antwerp-Congo-Antwerp; the increase of resistance was 9 per cent. after six months' service and was estimated at 12 per cent. after a year. The increase was not linear, which was confirmed by the Lucy Ashton experiments.

Concerning the Pitot traverses in the friction belt, he observed that there was a good correlation between the loss of momentum given by the velocity curves and the measured increase in skin friction due to fouling. That should encourage ships' officers, if a Pitot log was available, to take the velocity readings frequently in order to try to detect an increase in skin friction. Did the author find any correlation between his curves and some of the known theoretical curves, such as those of Prandtl, Schultz-Grunau, etc.? The author stated that, "whereas reasonably steady readings could be obtained when the log was set in the fully extended position, it was often difficult to obtain satisfactory readings when traversing through the boundary layer." How long did the experimenters wait between two successive readings? The instrument had a great inertia and some time would elapse before the mercury column and the needle found their new position. In the Tervaete and the Lubumbashi, when making a Pitot traverse, they often had to wait between three and five minutes before taking a reading; and a traverse in stages to the out position and back again would take a couple of hours, even in a calm sea. Often, in the past, experimenters had attempted to establish a ship's resistance by acceleration and retardation trials, but the big difficulty was the measurement of the quickly varying speed. Did the author consider that the Pitot log, with its great inertia, gave very accurate values of the speed? He was prompted to put that question by the low figure of 5 per cent. which the author gave for the added virtual mass. If account was taken of some inertia of the Pitot log, the percentage would become somewhat higher, more nearly approaching the values given by previous experimenters.

SKIN-FRICTION AND SMOOTHNESS

Professor S. J. Palmer, O.B.E., said that, to one concerned with the teaching of the subject of resistance and propulsion of ships, the conclusions of fundamental importance appeared to be (*a*) that Froude's assumption that skin friction and wave-making should be regarded as independent was justified, at least for the speed range $\left(\text{up to } \frac{v}{\sqrt{L}} = 1{\cdot}0\right)$ of the experiments; and (*b*) that Froude's law of comparison for residuary resistance was shown to be accurate over that range. Those conclusions might be overshadowed by others of practical importance in the papers, but the very basis of all model resistance experiments had been shown to be sound. Of great practical importance was the demonstration of the dependence of skin friction resistance on the smoothness of the wetted surface; and he would add that the maintenance of the smoothest possible surface was not less essential in warships than in merchant ships, since warships spent most of their time at sea at speeds at which the skin friction component predominated. It seemed probable that the sensitivity of skin friction resistance to the condition of the surface made it impossible to reach any firm conclusion on another object of the experiments, namely, the determination of the best basic turbulent skin-friction line. In fact, it might make them wonder why so much thought was given to that question, which was unlikely to affect ships' forms or to alter estimates of speed and power, while comparatively little attention was paid to obtaining really smooth hulls, which, the trials had shown, might yield very useful improvements in performance.

VIRTUAL MASS

Mr. W. C. S. Wigley, commenting on the question of virtual mass, thought that too much importance was often attached to Lamb's curve. It was probably correct for a spheroid moving, say, more than three or four diameters below the surface in a perfect fluid; but if that same spheroid were floating in a perfect fluid the result would be to diminish the curve of virtual mass. If it were desired to compare, with a theoretical curve, cases of floating bodies of ships, it would be much better to use the rather nearer curve for the floating body in a perfect fluid. Nevertheless, the experiments discussed in the paper suggested that the actual virtual mass in a perfect fluid probably had little effect comparatively; most of that apparent virtual mass must be due to disturbances of frictional flow. His reasons for that view were, first, that, if the virtual mass were due in any way to perfect-fluid considerations, it would almost certainly vary as the ship slowed down, owing to change of wave-making. Secondly, the spots on the author's graph would be expected to be lower. Further, he believed that, as mentioned in the paper, the fouling of the bottom did affect the virtual mass seriously. Taking that into consideration, the sort of pseudo virtual-mass effect must be due more to the frictional flow than to the perfect fluid flow which gave rise to the virtual mass of the text-books.

Professor E. V. Telfer said that Dr. Smith and his colleagues had been very positive that the present was the last of the Lucy Ashton papers. He could say with assurance that it was not the last. The paper concluded the presentation of the results; but they might be encouraged to give more of the data they had collected. He wished to discuss chiefly the lesson they were trying to learn in connection with fouling. Professor Palmer suggested that it was hardly necessary to have any precise use of friction lines. Dr. Telfer challenged that statement; they could only get to know something precise about the fouling of ships if they had a precise friction line. The Prandtl-Schlichting or Schoenherr lines gave quite a different characteristic for roughness from that obtained by using the Hughes line or his own line. The value of the paper was that it joined together the form of friction line and the form of the additive to smooth things up. From that point of view, the paper was disappointing, because, unfortunately, and inevitably, the fouling was not pure. Clearly, there would be rust starting in the first place, and half way through the experiment the sharp roughness of the barnacles came in; so the line was quite mixed in character, and he suggested that some of the conclusions were wrong. For many years he had kept up a statistical analysis of the fouling of merchant ships which had been in service for long periods; from that analysis, which included some hundreds of ships, there was no possible doubt that the ordinary roughness in service, which did not include barnacles as such, but was merely the deterioration of the surface between the ordinary dockings, did not progress uniformly with time. Early after dry-docking, it increased in rate, slowing down later.

The most satisfactory formula for statistical work appeared to be that the loss in efficiency was proportional to the square root of the number of days out of dry dock; at 100 days out, the loss of efficiency was, say, 10 per cent., and at 25 days the loss was already 5 per cent. It was interesting that a small amount of barnacles could cause quite a lot of resistance.

UNUSUAL FOULING CONDITIONS

Dr. J. F. Allan said that not the least important aspect of the work on the Lucy Ashton was that, the details had been published so fully that a lot more analytical work would be done, as Professor Telfer had indicated. Concerning basic friction lines, he agreed with Professor Telfer, but disagreed with Professor Palmer. The really significant point about the determination of the basic friction line was the question of what was the true roughness effect. The enormous increase of resistance due to fouling and the roughness which developed on the Lucy Ashton was very important; but they must keep the matter in true perspective and remember that the ship was tied up to a buoy in the Gareloch at the time of year when fouling was likely to be severe. He did not think it should be accepted as a general guide to the increase in roughness to be expected on a ship in service. Analysing the velocity distribution in the boundary layer, $\frac{u}{V} = \left(\frac{y}{\delta}\right)^n$, it would be found that the increase in the n coefficient was of the same order in the Lucy Ashton as it was in the Lubumbashi (dealt with in the paper by Professor Aertssen in his paper "Sea Trials on a 9,500 tons d.w. Motor Cargo Liner," presented later at the same meeting). That seemed to confirm the roughness measurements in the two cases. The general roughness gave a similar change in the velocity distribution in the boundary layer. In spite of that, there was a big distribution in overall resistance. He hoped that the B.S.R.A., having made such a success of the Lucy Ashton investigation, would be able to carry the good work further, to other types of ships.

Captain H. B. Ellison, C.B.E., D.S.O., R.N. (ret.), said that he had been interested in the remarkable effect of a small amount of fouling which recalled an experience of his own in that connection. In 1947 he was in command of

H.M.S. "Belfast," which lay in Hong Kong harbour for six weeks and was then ordered home. He wanted to carry out consumption trials on the way and left Hong Kong on the cruising turbines, but soon found that he could not reach the required speed. On arrival at Singapore, the ship was dry-docked and cleaned. She was not remarkably dirty, but all over the bottom there was a good layer of barnacles, amounting in some cases to about ½ in. It was suggested to him that the ship need not have been dry-docked, and that the trouble was that the propellers were covered with barnacles, causing cavitation. However, when the bottom had been cleaned they could immediately reach their speed on the cruising turbines alone, and with the greatest ease.

Professor S. J. Palmer, O.B.E., R.C.N.C., said that he wished to make it clear that he was not decrying the importance of attaining a reliable basic skin-friction line or suggesting that it should be abandoned or was not of fundamental importance. He intended merely to remark that, while it had been given a great deal of attention during recent years, perhaps they had not given a proportionate amount of attention to obtaining smooth hulls.

AUTHOR'S REPLY

Dr. Livingston Smith, replying to the discussion, said that it was a great encouragement to a relatively new organisation like the British Shipbuilding Research Association to receive such praise from so many experts on the subject. Dr. Gawn raised the question of the proper size of model. They did know which geosims were too large for the No. 1 tank at the National Physical Laboratory, but what would be too large for other tanks he would not like to conjecture. With regard to the question of virtual mass, he was glad to have Dr. Gawn's approval. They knew, of course, that locked propellers could have a very great effect; but on that subject also a great deal more work was needed. In reply to Professor Aertssen: the figures given might seem high, but they were the figures for the Lucy Ashton under the conditions of the test. He agreed that many variables affected the problem, but Professor Aertssen's own work was helping greatly to fill some of the gaps. He also raised the question of the time interval between observations with the Pitot logs. That was certainly important. Dr. Livingston Smith could not recollect exactly the times taken, but they waited long enough to get a steady reading. He promised to reply more fully on that point in writing. He agreed with Professor Palmer that surface roughness had not always received the attention it merited; and with Mr. Wigley, that Lamb's results could almost be misleading if the free-surface effects were forgotten. Virtual mass might arise from disturbances in the frictional flow, and Mr. Wigley's arguments on that score appeared to be sound.

Dr. Livingston Smith declined to be drawn into the "Palmer *versus* Telfer" dispute on the skin-friction line, saying that he had given the facts about the fouling on the Lucy Ashton, and the mixture of grasses and barnacles, but the statistical analysis of ship results was quite another matter. Other B.S.R.A. work referred to by Professor Telfer was devoted to ship fouling in service, which was quite different from the conditions applying to the Lucy Ashton in the experiments described. In their experience little fouling occurred during the first ten days; but the amount depended on the localities, and other factors. He would reply to the other points in writing.

The chairman, in thanking Dr. Livingston Smith for his presentation of the results in the paper, said that the Institution was immensely indebted, not only to the B.S.R.A. for its initiation of the work and for the experiments, but to all who had been concerned with it. They now had the whole of the results in four parts; but, as Professor Telfer had said, that was only the beginning of the work of statistical analysis.

(To be continued)

The Institute of Metals Spring Meeting *(continued from page 471)*

CONTROL OF QUALITY IN WROUGHT NON-FERROUS METALS

HEAT-TREATMENT AND FINAL OPERATIONS

Continuing our report of the spring meeting of the Institute of Metals, which took place in London from March 29 to April 1, we have now to deal with the all-day symposium on "The Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys. III.—The Control of Quality in Heat-Treatment and Final Operations." This had been arranged by the Institute's Metallurgical Engineering Committee and was held on Thursday, March 31; it constituted programme "A" for that day. The symposium contained six papers which were introduced by a *rapporteur*, Dr. A. R. E. Singer. The President, Dr. Maurice Cook, occupied the chair at the morning session.

In the course of his introduction of the papers, Dr. Singer said that the present symposium was the third in a series which had dealt with the production of wrought non-ferrous metals and alloys. The first one, in 1953, had referred to the melting and casting of non-ferrous metals, and, last year, there had been one dealing with working operations for wrought non-ferrous metals. Hence, the present symposium was the logical conclusion of the series.

The first of the six papers dealt with "Assessment of Quality of Wrought Products," and was by Dr. W. G. Shilling, M.C., of the Aeronautical Inspection Directorate (Materials Division), Ministry of Supply, Harefield, Middlesex. Dr. Shilling gave an outline of the system of inspection used by the Directorate and made observations on various aspects of inspection such as sampling and methods of test at various stages of production. He emphasised that the aim of a specification was to provide uniform material.

The second paper, "The Control of Quality in Heat-Treatment and Final Operations in the Production of Rolled, Extruded and Drawn Aluminium and Aluminium Alloys," was by Mr. A. J. Field and Mr. J. Salter, of the British Aluminium Company, Limited. The authors stated that their paper was devoted to a consideration of such operations as sheet shearing from coil, flattening, finish shearing, slitting, blanking, the straightening of sections, the drawing and finishing of tubes, and inspection and packing. Many qualities were affected by earlier processes and if the quality of the product had not been properly controlled in the early stages, it was often impossible to rectify the damage in the heat-treatment and final operations. For example, in the latter processes, it was not possible to correct gauge variation which had occurred during rolling; nor, in general, could faulty properties resulting from incorrect temper-rolling conditions be subsequently rectified. Some departures from the desired quality caused by inadequate control in the earlier processes, however, could be put right in the later ones; for example, an imperfect as-rolled shape might be corrected to some extent in the final operations.

Light-alloy products were more susceptible to damage than harder metals and, in addition, the end uses made of light alloys demanded a high surface quality. In consequence the light-alloy product, throughout all stages of production, must be handled with more care than other metals. For example in processing flat sheets, particularly thin ones, it was customary to interleave the sheets with tissue paper or brown paper throughout all final processing, from flattening onwards.

"Heat-Treatment and Finishing Operations in the Production of Copper and Aluminium Rod and Wire" was the title of the third paper in the symposium. It was by Mr. H. J. Miller, engineering manager, Metals Division, British Insulated Callender's Cables, Limited, Prescot, Lancashire, who stated that, to a large extent, his paper was devoted to products manufactured for electrical requirements. Surface condition was a feature which was most affected by the early processing operations, and, with both copper and aluminium, careful attention must be given to the choice of fabrication methods, the quality of the initial castings, preheating conditions for hot working, dimensional control in hot working; the surface condition of the hot-worked product, surface-improvement processes, and subsequent cold-working operations. If the conditions were unsatisfactory in preceding operations, the final product might be of poor quality, notwithstanding perfect control in the final heat-treatment and finishing stages.

Although wire might be considered as a finished product, it generally had to undergo much further processing before it emerged in the form of a marketable engineering product. Of foremost importance were inspection, packaging and re-winding. Because there had been only a limited use of aluminium and aluminium-alloy wire—apart from the important application for overhead conductors—techniques for some time were likely to remain fluid. This was true of the whole of the procedure involved in fabrication and related operations; as well as to the practice in the user industries.

The fourth paper bore the title, "The Control of Quality in the Heat-Treatment and Finishing of Copper and Copper-Base Alloys." It was by Mr. V. B. Hysel and Mr. T. B. Collier, of Thomas Bolton and Sons, Limited, Froghall, Stoke-on-Trent, who stated that their aim was to discuss some of the problems that arose in the heat-treatment and finishing processes in the manufacture of copper and copper-alloy sheet and strip, sections, and tubes. The final processes included shearing, straightening, cutting to length and the removal of burrs. During the straightening process the mechanical properties of wire and rods generally underwent some modification, the extent of the change depending on a variety of factors, including alloy composition, the degree of cold work applied, and the machine setting. If, however, the material were subjected to a low-temperature heat-treatment before straightening, the mechanical properties suffered little or no change during the straightening process. It was essential that all unnecessary handling and movement of finished material, especially in the soft or semi-hard state, be avoided. For this reason, apart from considerations of efficiency, the warehouse was normally sited at, or near to, the end of the production line.

"The Production of Light-Alloy Drop-Forgings, their Heat-Treatment, Inspection and Testing," was the title of the fifth paper. It was by Mr. W. T. Edmunds and Mr. R. C. Lloyd, of Light-Metal Forgings, Limited, Oldbury. These authors stated that the dimensional tolerances for forgings had become smaller, and users had come to demand that the strength and other metallurgical features of forgings should be accurately known. Close liaison now existed between the designer and the forging manufacturer, from the drawing-board stage. During recent years, specifications had been introduced which necessitated a full metallurgical investigation into every type of forging.

The raw material for making aluminium-alloy drop forgings could be extruded, cast, rolled, or pressed. In all cases it was desirable that the original casting should have been produced by the continuous-casting process. Extruded bar, if free from defects, was the most suitable general-purpose stock, especially for small stampings. Rolled bar was considered to be

preferable to extruded bar for making stampings free from coarse grain, and cast or, to a greater degree, pressed stock was useful for making forgings larger than could conveniently be made from extruded stock.

Solution treatment of the alloys was carried out at temperatures between 460 deg. and 550 deg. C., and precipitation treatment between 120 deg. and 220 deg. C. After heat-treatment, forgings were covered with a coating of oxide which must be removed before they could be efficiently inspected. To effect this the forgings were immersed for several minutes in a 10 per cent. solution of sulphuric acid containing small additions of hydrogen or sodium or potassium fluoride, at about 20 deg. C. The pickling treatment was followed by a cold-water rinse and the forgings were finally washed in warm water, so that they dried almost immediately.

Crack detection was facilitated by the anodic oxidation of the forgings, using the chromic acid process, and it was general practice to carry this out on all finished aircraft forgings. Generally speaking, internal cracks could be detected only by ultrasonic testing.

The development of the ZW3 (D.T.D.729), magnesium-zinc-zirconium alloy had made possible the production of high-strength drop-forgings. The technique employed was, in general, the same as that for aluminium alloys. The forging temperature range was 300 deg. to 500 deg. C., and the preheating equipment was the same as for aluminium alloys.

The sixth, and last, paper in the symposium dealt with " The Heat-Treatment, Inspection and Testing of Wrought Nickel and Nickel Alloys." It was by Dr. W. Betteridge of the Mond Nickel Company, Limited, and Mr. T. E. Cound, of H. Wiggin and Company, Limited, Birmingham, who stated that nickel-alloy bar was hot-rolled to sizes from about 4 in. to 0·375 in. in diameter; broadly speaking, the methods used were those normal in rolling steel. For sheet and strip, machined ingots were initially hot-worked either by breaking down on a universal mill or by extrusion. The sheet bars were then hot rolled on a three-high sheet mill, the finer gauges being finished by pack-rolling. Before cold rolling, the sheet was either bright- or batch-annealed. Wire in all the alloys was drawn from hot-rolled rod, 0·375 in. in diameter. In all nickel alloys, tube was produced by initial hot extrusion, followed by cold drawing.

Final heat-treatment consisted of annealing, normally applied to sheet or wire products to soften them for subsequent working operations, and hardening, comprised a solution treatment followed by a precipitation treatment.

Three methods of non-destructive testing for internal defects were employed, namely, radiographic, which, however, had largely been replaced by the second method, ultrasonic testing, and eddy-current methods which had proved to be of great value in the examination of bar.

A wide variety of special routine tests of physical and mechanical properties was applied to nickel alloys. Some were carried out to satisfy official specification requirements; others to meet the needs of particular customers. These included tests on magnetic alloys, controlled-expansion alloys and electrical-resistance alloys. Other tests were for determining thermoelectric properties and the creep resistance of materials.

DISCUSSION

Mr. S. S. Smith, who opened the discussion, said that there must never be control for its own sake, but that effective control, whether automatic, statistical, operational or dependent on the skill and integrity of the operator, must be directed to the prevention of error. A brief reference was made in some of the papers to the control of chemical composition, but there was little comment on the standards and accuracy of the control procedures involved or on the specifications, as such, with which the writers were concerned.

Messrs. Field and Salter had touched upon details which were often neglected in describing how finish was maintained. They had, for instance, advocated that the burr on the leading edge of sheets from the flying-shear and levelling operations should be uppermost when piling the sheets, so as to avoid scratching. There were two questions that he would like to put to them. First, had they made use of devices such as those suggested by the Royal Aircraft Establishment for the assessment of flatness in a sheet? Secondly, had they any views on the use of controlled atmospheres to minimise staining of aluminium-magnesium alloys during annealing, or did they prefer flash annealing? An oxygen-free atmosphere was mentioned by Messrs. Field and Salter, but other authorities suggested that oxygen prevented staining by carbon. This subject of staining in heat-treatment was still of vital importance, even in salt baths.

The nickel alloys were known to him only as a customer, but he was impressed by the description by Dr. Betteridge and Mr. Cound of the control methods used in their production. It was made apparent that, having regard to the prime cost of the materials involved, standards must be rigid, with ruthless rejection of faulty material at the earliest possible stage.

He was pleased to note that all the authors have paid attention to packaging as a final gesture to win the confidence of the customer, who was still " always right."

Dr. G. E. A. Bramley said that the problem of " burnt-oil " stain after annealing was as serious a one with aluminium and aluminium-alloy wire as it was with strip; it was perhaps even more prevalent with the thicker-gauge wires owing to the necessity for using relatively high-viscosity drawing lubricants. By using a thinner and more volatile lubricant, coupled with a lighter reduction on the last die, it was possible to minimise the amount of oil on the wire going to the furnaces, thereby reducing the incidence of " burnt-oil " staining. Where annealed wire was to be flattened to strip, the presence of " burnt-oil " stain, even if only slight, was a serious handicap to holding reasonably close tolerances on the width of such strip. The presence of the carbonaceous deposit on the surface of the wire affected the friction in the roll-gap and thereby influenced the degree of spread obtained.

It was believed that strand-annealing could be of assistance in this problem, and it would be interesting to hear from the manufacturers of strand-annealing plant of their experience in the application of such equipment to the annealing of aluminium and aluminium-alloy wires in sizes ranging from about ⅛ in. in diameter down to 36 s.w.g. In connection with the annealing of copper wire, Mr. Miller, in his paper, mentioned the method of strand-annealing in tandem with wire-drawing at speeds of 2,000 ft. per minute and upwards. It would be of particular interest to have the views of the manufacturers on their experience of the application of this tandem method to aluminium and aluminium alloy wire.

Fairly large quantities of high-strength, heat-treatable aluminium-alloy wire were supplied in straight lengths for machining in automatics. Here the material was solution-treated in coil, prior to straightening, and difficulties were sometimes experienced owing to the coil settling down under its own weight at the solution-treatment temperature, resulting in the formation of short kinks or even actual indentations where one lap crossed over another. Such kinks, once formed, could not be removed in the usual type of spinner straightening machine and, for applications where a high degree of straightness was required, as, for instance, where the rod had to be centreless ground, such kinks usually led to rejections. No mention was made of this effect in any of the papers dealing with wire.

Mr. H. Chadwick, speaking on the paper by Messrs. Edmunds and Lloyd, referred to the problem of the occurrence of blisters on forgings manufactured from extruded stock, particularly those produced to specification L.64 or L.65. He believed that the blisters could be divided into four main types, namely, those arising from faulty stock, those due to insufficient lubrication in the die during the forging process itself, those produced by overheating during preheating or heat-treatment, and those resulting from a reaction with the furnace gases during solution heat-treatment. It was very difficult to decide on the cause of the blisters from their appearance on the surface of the forging and it was misleading to try. Microscopic examination afforded a ready means of differentiating between the causes and once these had been established a cure could be effected.

Mr. K. E. Thompson said that a non-destructive testing method which could be regarded as complementary to ultrasonics was the one based on eddy currents. This had been used more widely in Germany than in this country for the evaluation of variations in hardness and composition and for flaw detection. Despite the present limitations, there was no doubt whatever of the value of ultrasonic testing, and although eddy-current testing was still very restricted in its application, these two methods together would form a very important part of the inspection programme. Anything that could be done to reduce or remove the limitations, however, would make the interpretation of results much easier and would help metallurgists to make a more accurate assessment of the quality of their products.

Mr. A. W. Matthewson said that inspection should be of a positive and not a negative nature; it should take part in production, it should advise the production side, but it should not be under the control of production.

AUTHORS' REPLIES

Dr. W. G. Shilling, in reply, said that it had been suggested that if they insisted on inspecting every part of the process and, having done so, found that the manufacturer had carried out all of them to their satisfaction, they ought to accept the final result whether it was good or not. He did not agree. They were not responsible for the process. A manufacturer, on finding that a process did not give him the answer he wanted or the answer that his customer wanted, would just change the process.

It was true that some of the aeronautical specifications appeared to be somewhat wide. There was a reason for that; if they were not, thousands of specifications would have to be drawn up instead of hundreds. That did not mean, however, that a manufacturer, if he valued his products, would be quite happy to be within these wide limits in his normal manufacturing process. He would, from experience, control his limits very much more closely than those given in the specification.

Mr. W. T. Edmunds, in his reply, said that there was a difference between the practice in the United States and the practice in this country. In Great Britain, there was not the demand for the enormous number of forgings which was typical of United States production, and therefore, in this country, the production of forgings was strictly individual. From that point of view, there could not be, in the forging field of operations, the same demand for intensive instruments for the detection of flaws. Quality in forging depended upon the past history of the material. The defects which could arise in the forging operation were relatively few. Hence, quality was expressed chiefly in the material placed in the forger's hands. Die life depended largely on questions of design and mass; temperatures were secondary.

In his reply, Mr. J. Salter said that he would like to clear up any misconception that their main inspection department was concerned in any way with production or had any responsibility for production. It had not. It was responsible to the general management of the factory. Its contacts outside the factory were direct with their selling organisation and therefore with their customers. The inspection was divorced from matters of economy and output, but it did observe standards set by the general management of the company.

Mr. Smith had asked whether they had any experience of the R.A.E. assessment of flatness;

flatness was judged by them visually, and, in bad cases, by feel. The sheet was laid flat and viewed at a very acute angle to the surface of the sheet. Mr. Smith had also raised a point concerning their experience with controlled atmospheres and their comment that an oxygen-free atmosphere had its use or was desirable. He (Mr. Salter) admitted that there was some difference of view within their company as to the precise purpose of a controlled atmosphere and what it did. They did not use furnaces with controlled atmospheres, but they had seen them in use elsewhere, and from other users had not been able to find out what particular surface a controlled atmosphere was giving.

At this stage the proceedings were adjourned until 2.30 that afternoon.

(To be continued)

MODERNISING FRENCH RAILWAYS

The distinguishing feature of engineering progress on the French railways since the war—apart from the civil engineering work of restoring damaged viaducts, bridges, stations, yards, etc.—has been the great extension given to electrification and especially to the application of the 25,000-volt 50-cycle system.

Encouraged to investigate its possibilities by seeing the equipment on the Höllenthal line in Germany, French engineers applied it to a secondary line between Aix-les-Bains and La Roche-sur-Foron with considerable success, carrying out very valuable research work there. At first it was thought that the system would be more particularly applicable to lines of the same general type, where annual savings in coal would not suffice to justify the 1,500-volt direct-current system, already in use for some years on important main-line routes and applied since the war between Paris and Lyons (320 miles) on the line to Marseilles. Such rapid progress, however, was made with the 25,000-volt alternating-current equipment that it was decided to use it for the important north-to-east main line between Valenciennes and Thionville and the first train ran between the former place and Charleville on July 18, 1954.

A few months earlier official sanction had been given to equipping what is called the second north-to-east route, extending from the first, westward to Lille and eastward through Metz to Réding, the junction of the lines from Thionville and Paris to Strasbourg. The total length of these two north-to-east sections is 444 miles. Shortly after this a convention was signed in Berne by which Swiss financial assitance was obtained for carrying electric working through from Réding to Basle, 130 miles, so connecting Switzerland to the frontiers of the Benelux countries by electric services. Finally, in July, 1954, the railways laid before the Minister of Public Works, who signified his approval in November, what is known as the Nord-Paris scheme, connecting Lille with the capital through Amiens (Longueau) and Creil, 340 route miles.

The North and East Regions of the national railway system cover one-fifth of France and contain over 25 per cent. of its population, but in them originate more than 40 per cent. of all receipts. Freight traffic is particularly heavy, two-thirds of the total tonnage coming from these regions and accounting for 80 per cent. of their own receipts. It was well known that it would pay to electrify but many reasons—strategic, technical and economic—combined for a time to prevent anything being done. Changed conditions have now, however, deprived the strategic arguments of all their force. Traffic along the north-eastern frontier is especially dense by reason of the number of coal and iron mines, blast furnaces, the presence of potash and salt deposits and industries producing chemicals, fertilisers, etc. There is a heavy importation of fuels, while Dunkirk and Strasbourg stand fourth and fifth for activity among French ports. Electric power supplies are well developed in the area and are being extended, with both hydraulic and steam generation, and 50-cycle current is obtainable readily all the way from the Pas de Calais to Alsace. It was in consequence decided to use the 25,000-volt system for all these lines and for the other project, now being examined, the Est-Paris, from the capital to Metz and Réding, 352 miles, making a grand total of 1,266.

A principal problem was to obtain, with as few separate designs of parts as possible, locomotives meeting the requirements of the Operating Department efficiently and economically without, however, attempting to attain specially high maximum speeds. Ordinary heavy freight trains—most numerous between Valenciennes and Thionville—are limited to a little under 50 m.p.h. On easily graded sections, loads of 2,200 tonnes are hauled and this figure could be increased nearly 10 per cent. by electrification, while maintaining better average speeds. Express freight trains are allowed to reach 60 m.p.h., using special stock, and are more frequent between Paris and Lille, Paris and Strasbourg, and Thionville and Basle. Their load seldom exceeds 800 tonnes, and the express passenger locomotives could deal with them. On certain sections, passenger trains can reach something over 85 m.p.h., and others can be made suitable for that by certain small alterations to the layout. Local sevices are not numerous and can continue to be worked by railcars. It is not for the moment intended to electrify the suburban services out of Paris (Nord) and no motor-coach stock is contemplated.

Four types of locomotive were obtained for the initial Valenciennes-Thionville section, in each case having all wheels driving, namely: (1) a CC having a converter and direct-current motors; (2) a CC having a converter and three-phase motors (maximum speed in either case 37 m.p.h.; (3) a BB with 50-cycle alternating-current motors (maximum speed 65 m.p.h.; and (4) a BB with rectifiers and direct-current motors (maximum speed 75 m.p.h.). To these are being added a BB with 50-cycle motors, able to attain 75 m.p.h., by modifying the gearing and main transformer, and another capable of about 85 m.p.h.

These machines differ from those seen on the direct-current electrified lines in having one central cab, with lower casings to front and rear housing the principal items of equipment, effecting a saving in cost of about 10 per cent. Standardisation has been introduced for such components as pantographs, compressors, generators for accumulator charging, contactors, oil pumps, heater equipment, relays, switchgear, fuses, etc. The converter-type locomotives can operate regeneratively on down gradients. At present 160 locomotives are in service or on order, but the total contemplated is 327.

For the 914 miles which are being or are authorised to be operated electrically, 23 sub-stations suffice as against the 26 which were needed for the 195 miles between Paris and Dijon with the 1,500-volt direct-current system. Some are located in the grid transformer stations, others at a few miles distance from them. Very few lengths of high-voltage feeder have been necessary whereas on the direct-current sections one had to be run throughout. To avoid risk of unbalance on the 3-phase supply, Scott connected transformers are used, giving two single-phase supplies in quadrature, one on each side of a sub-station. It may prove possible later, however, to take a straight single-phase supply, as to ordinary consumers. Sub-stations and sectioning and paralleling posts are remotely controlled, at present from Charleville, but additional control points will be provided at Douai and Metz. The overhead construction supports a grooved copper contact wire with bronze carrier cable, equivalent to 150 sq. mm. copper, compared with 500 to 1,000 sq. mm. for Paris-Lyons, and its relative lightness results in less interference with signals than usual. It was necessary to lower the track in tunnels to obtain adequate clearances and render the arches water-tight, especially near contact-wire supports. The pantographs are rather narrower than usual, necessitating a certain amount of duplication of contact wires at points and crossings.

Telecommunications circuits, railway and postal, have had to be cabled and much modernisation of signalling undertaken, but as a great deal of that was obsolete, or costly in operating staff, appreciable economies have resulted from installing the latest equipment. The direct-current track circuits have been retained to some extent, but generally the alternating-current type, using 83-cycle current, has had to be used. A more recent development, likely to become standard, uses 1,000-cycle current in association with electronic equipment, and eventually automatic signalling, already in extensive use, especially in the Eastern Region, will be complete between Paris and Strasbourg.

As the change to electric traction itself increases the capacity of the lines, much reconstruction of stations and yards, at one time envisaged, has been avoided and in some cases simplification has been possible. At Metz-Ville, for example, over 4 miles of sidings and 53 sets of points have been eliminated. Savings totalling over 3,100 million francs have been effected in this way without any adverse effect on train services. Electric working is expected to be in full operation between Valenciennes and Thionville by July. The locomotives have functioned extremely well and very few modifications—and those small—have proved necessary. The coal saved when the authorised work is completed should be about 1,030,000 tonnes annually, which will be replaced by an average of 650 units of electric power per tonne, giving an annual saving in fuel (power) costs of 3,700,000,000 fr., to which others must be added, calculated to produce a return of at least 11 per cent.—14·5 per cent. for Valenciennes-Thionville—on the plan as authorised, not to speak of the benefits to the localities traversed and their industries resulting from the elimination of steam.

There are now only 6,530 steam locomotives on the National Railways compared with 15,235 in 1938. The purchase of 2,000 up-to-date machines after the war enabled many old designs to be scrapped. With 57 per cent. fewer, the number of classes has fallen to a third of pre-war figures, with great economies in maintenance. Engines released by electrification are being used to improve the working on lines of medium traffic. Improvements in signalling and station layouts have made welcome accelerations possible. Diesel traction is being extensively applied to shunting, particularly in large yards where the ability to regulate speed very closely and stop and start quickly is especially valuable. On secondary lines also Diesel traction is being systematically extended, a notable example being on a group of routes radiating from Orleans. High or medium speed, railcars, running singly or in trains, have been in use for some time, of course, and an interesting example of a new service is that joining Geneva and Digne, connecting there with Nice by other cars belonging to a privately-owned line.

An important use for Diesel locomotives has been found on the northern half—the southern is electrified—of the Grande Ceinture connecting line round Paris, which carries a very heavy interchange freight traffic and occasionally special passenger trains. At times saturation point is reached. Much of the traffic also is short-run and calls for frequent marshalling, with numerous light-engine movements. Twenty 2,000 h.p. Diesel locomotives are being obtained, able to run some 120 miles daily against the 50 performed by a steam locomotive, with considerable cutting of journey times.

With these and other improvements has gone much modern signalling work. The new relay interlocking signal box at Marseilles (St. Charles) opened on December 8 last, is the largest of this type in France, controlling 450 routes and replacing 7 other boxes, with a saving of 67 signalmen. Capital is thus being everywhere wisely expended in the conviction that the only alternative would be stagnation and eventual decline.

PROTECTING IRON AND STEEL BY SPRAYED ALUMINIUM OR ZINC

NOTES ON NEW BRITISH STANDARD

By F. A. Champion, PH.D., B.SC., A.R.C.S.*

The first two parts of a new British Standard on sprayed metal coatings (B.S. 2569/1955) have been issued recently. Part 1 provides for the "Protection of Iron and Steel Against Atmospheric Corrosion," particularly where liquid water may be involved in the corrosion process; Part 2 provides for "Protection of Iron and Steel by Aluminium Against Corrosion at Temperatures between 120 and 950 deg. C.," for example, high-temperature oxidation or corrosion by hot sulphurous combustion products. The following comments may assist in the interpretation and use of this Standard. General information on sprayed coatings is available elsewhere.[1]

Moderate Temperatures.—Both zinc and aluminium coatings provide initial physical protection followed by sacrificial protection if and when the steel is exposed, and both metals are therefore specified in Part 1 of the Standard. The sacrificial protection increases as the coating thickness increases, as is indicated in the following Table which quotes values extracted from results obtained by the British Iron and Steel Research Association.[2] The life given in the Table is the time required to give definite and

Life (years)	Sprayed Coating thickness (mils)	
	Zinc	Aluminium
2	1	1
4	2	2
10	5	3

permanent rusting in a severe industrial atmosphere (Sheffield).[2] For a given coating thickness the life increases as the atmospheric conditions become less severe, but since quantitative evidence in this respect is still inadequate, no attempt is made in the Standard to relate coating thickness to types of atmosphere. With thin aluminium coatings, and especially in relatively mild corrosive conditions, superficial rust staining may occur in the first few hours or days of exposure; although this soon ceases and the stain disappears within a few weeks, it is apt to give rise to doubts on the protective value of the particular coating. Increase in thickness of the coating decreases the chances of interconnected porosity leading down to the steel and thus provides an appropriate precaution against this superficial effect: 4 mils (0·004 in.) has been found to be a suitable thickness for this purpose.[3] Taking all these factors into consideration, the minimum thicknesses for unpainted metal coatings have been given in the Standard as 3 mils for zinc and 4 mils for aluminium.

An excellent basis for painting is provided by these sprayed coatings, particularly the aluminium coating which gives excellent paint adhesion without pre-treatment. For this purpose the sacrificial protection is called into play only for short periods, when the paint is awaiting repair, and rust staining of the aluminium does not arise. Consequently the specified minimum thickness of 2 mils is adequate for both metals. The paints should be chosen to be compatible with the metal of the sprayed coating; lead pigments should be avoided and a zinc chromate primer will be most effective for the most severe conditions.

Alternative purities of 99·0 per cent. and 99·5 per cent. (minima) are given in Part 1 of the Standard for aluminium coatings. The higher purity gives rather better protection due to its higher intrinsic corrosion resistance, but the extra cost may not always be justified for every application.

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Elevated Temperatures.—Zinc coatings are unsuitable for use above about 120 deg. C., so that Part 2 of the Standard is confined to Aluminium. For the highest temperatures the coated steel should be heat-treated in a relatively non-oxidising atmosphere before going into service. During this heat-treatment the sprayed metal is converted to an alumina film overlying an iron-aluminium alloy layer. The Standard provides three alternatives for achieving suitable atmospheric conditions during heat-treatment:—

(*a*) Use of a furnace holding a reducing atmosphere.

(*b*) Prior painting of the metal coating with bitumen which gradually burns off during the heat-treatment.

(*c*) Use of aluminium-cadmium alloy in place of pure aluminium for the coating. The cadmium preferentially volatilises and oxidises.

Where the service temperature does not exceed 550 deg. C. satisfactory protection can be obtained without prior heat-treatment, although the latter would have no disadvantage for such service conditions.

Protection is dependent on the maintenance of an alumina film by the reserve of aluminium in the iron-aluminium alloy and it has been found that a 5 to 10-mil coating, as sprayed, gives a suitable alloy layer.

General Comments.—Attention is also drawn in the Standard to the importance of ensuring at the design stage that the article is suitable for metal spraying, particularly in respect of its shape: a slight and otherwise unobjectionable change in shape on the drawing board might have a considerable affect on the cost or effectiveness of the sprayed coating. Some shapes are liable to give difficulty in measuring coating thickness on some parts of the article, and provision is made in the Standard for such measurements to be omitted in these cases. For the majority of work, however, thickness checks can be made with commercial accuracy and are to be recommended.

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10-TON FATIGUE TESTING MACHINE

LOAD PROVIDED BY MASS AND SPRING SYSTEM OSCILLATING RESONANTLY

By H. L. Cox, M.A., A.M.I.MECH.E., *and N. B. Owen*, A.M.I.MECH.E.

This article describes a mechanical fatigue testing machine of 10 tons load range which operates at the resonant frequency of a mass-spring system, at about 2,000 cycles per minute. The mass-spring loading element is driven by means of a crank and connecting rod through a friction clutch. At starting this clutch may be permitted to slip, so that resonance can be reached without overloading the drive unit, which is of relatively light construction. In the present machine the throw of the crank, by which the load range is determined, may also be varied while the machine is running. By this means the range of load may be increased after the machine has been set in resonant vibration at a smaller range.

The machine has completed over 650 million stress cycles mainly in tests on chains under pulsating loads. The results of the tests on short-link ¾-in. and 1-in. diameter wrought-iron chains are included in the article.

Any testing machine comprises essentially three parts, namely, a frame supporting and in some degree guiding the two testing heads or platens, a straining mechanism to apply the desired load and a weighing mechanism by which the magnitude of the load is measured. For a static machine the straining mechanism must of course be capable of affording the full load desired, and the means usually adopted are either a hydraulic ram, or a screw driven through reduction gearing. For a fatigue testing machine also, a direct hydraulic or magnetic drive may be employed, but it is not strictly necessary to make the drive thus powerful because, by the use of a mass spring system, the strain at maximum load may be converted every quarter cycle into kinetic energy stored in the mass, in which case the drive need only apply sufficient force to maintain the oscillation.

In the schematic arrangement shown in Fig. 1 the load is developed by strain in the spring K and is transmitted through the head M to the test-piece K_s, the remote end of which is fastened to the frame F. At slow speeds the drive D would of course have to exert the full load $\pm Kr$ corresponding to the deflection of the spring of stiffness K through the throw of the crank $\pm r$. On the other hand, if between the drive D and the spring K a mass m is attached, at speed w the effective stiffness of the mass-spring system is $K - mw^2$ and by adjusting m, or w, or both, the load in the drive may be reduced to any degree desired.

STARTING PROBLEMS

The arrangement shown in Fig. 1 would be quite satisfactory once it was running at speed w such that $K - mw^2$ was zero or nearly so; at that speed the reaction on the drive would depend principally on the frictional and other non-elastic losses in the complete system, and these considerations alone would impose limits on the amplitude of vibration $2r$. The difficulty, however, is to attain this condition of speed and amplitude from rest, because in starting up at amplitude $2r$ the drive and connecting rod would have to exert the full load $\pm Kr$.

In order to avoid this difficulty, the direct drive by crank and connecting rod may be replaced by an electromagnetic (loudspeaker) unit or by an out-of-balance exciter. Such types of drive apply to the oscillating mass (m in Fig. 1) a periodic force, and the required amplitude of vibration may be built up from rest over a few hundred cycles, during which period the drive is loaded only slightly more heavily than during steady running. On the other hand in this system the exciter is effectively decoupled from the oscillatory system in the sense that the amplitude of vibration of the latter has no direct reaction on the drive, and that for a given excitation in terms of force and frequency the amplitude of vibration is determined in part by the difference between the impressed and resonant frequencies, and in part by the damping of the vibratory system. If such a system were run actually at resonance, the amplitude would be determined entirely by damping, and the load range could be controlled only by deliberate variation of the damping. Provided that the inherent damping is not liable to vary too violently, this system might be feasible, but it does not seem ever to have been used. In present-day practice machines fitted with a force-exciter run off resonance—usually just

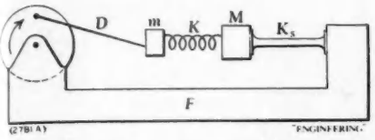

Fig. 1 Schematic arrangement of fatigue testing machine.

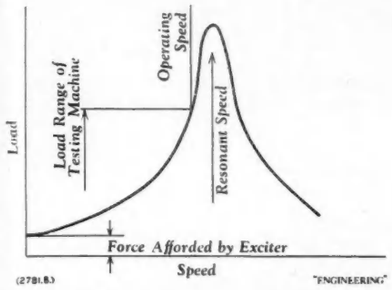

Fig. 2 Relation between operating and resonant speeds for a force-excited machine.

below—and control is effected by varying the speed. However, since the whole virtue of the mass-spring system is to afford a high ratio of load in the spring K to load in the exciter, it is inevitable that the operating point must lie well up a steep resonance curve, as indicated in Fig. 2, so that a very high standard of speed control is essential.

THE DIRECT DRIVE MACHINE

If the arrangement shown in Fig. 1 is operated at the speed w_0, where $w_0^2 = \frac{K}{m}$, and if M be equal to m, the range of load imposed on the test-piece is independent of the stiffness, K_g, of the test piece and is simply $\pm Kr$, where r is the throw of the crank; the true resonant frequency, w_1, is, however, slightly less than w_0 and, approximately, $w_1^2 = \left(\frac{K_g}{K + K_g}\right) w_0^2$. Provided that the ratio $\frac{K_g}{K}$ is kept moderately large (>10 say), the variation with speed of the load range imposed on the test-piece over the range w_1 to w_0 may be rendered quite inappreciable, and then the sole requirement for close control of the load range during a prolonged test is to maintain the crank throw, r, constant. The direct-drive machine therefore needs no speed control.

In order to start the machine, two means are available. One is to connect the drive D to the mass m, not directly as indicated in Fig. 1, but through a clutch. When the motor drive is started the clutch will slip, and slip will continue until the speed range w_1 to w_0 is attained. Then the periodic drag in the clutch will begin to build up the oscillation of the mass m just as the electromagnetic pull does in the loudspeaker drive. However, when the mass m attains the amplitude $\pm r$, slip in the clutch will cease and the machine will continue to run at the same amplitude without further slip unless the speed of the drive changes so much that the static friction in the clutch becomes insufficient to transmit the load in the connecting rod. Moreover the drive is close-coupled to the oscillatory system (K, m), so that the latter, acting as a flywheel, very markedly limits variations of speed of the drive; variation of electrical input to the operating motor, which with the motor running light might cause 10 per cent. variation of speed, may, when the motor is coupled to the oscillatory system, affect the speed by only a fraction of one per cent.

The slipping-clutch system works well in a small-capacity machine with a very simple spring-loaded clutch, which is preset. For a larger machine a magnetic or hydraulic clutch, which could be operated after the speed range w_1 to w_0 had been reached, would probably be preferable. However, for a larger machine, of which the size justifies the extra cost, another method of drive in which the throw of the crank is made variable while the machine is running offers advantages.

10-TON PROTOTYPE

Illustrations of the prototype machine constructed at the National Physical Laboratory to demonstrate the principle of direct drive are shown in Figs. 3 and 4, and a key to these photographs is afforded by the schematic diagram of the layout shown in Fig. 5. The machine is built upon the base of a Schenck machine which had come into the possession of the Laboratory in 1945, without sufficient parts remaining to permit its reconstruction according to the original design. The base is a fabricated steel unit approximately 10 ft. long, 3 ft. high and 3 ft. wide overall, and it weighs about 8 tons.

The four springs, used in pairs to afford the range of load and the mean load, are railway-wagon drawsprings, which were supplied by the Railway Executive, Western Region; the ends of these springs were ground flat and parallel at the Laboratory but otherwise they are used just as supplied.

In the machine (Fig. 5a) the test-piece *a* is mounted between the existing fixed head on the machine base *l* and a loading head *e*, rigidly attached to a loading rod *b*. This rod extends to the remote end of the base *l* along the centre-line of the machine, and on it are mounted both the dynamic and static spring-loading elements; at the test-piece end, the rod is guided by a flexible plate *s* mounted upon the base *l*, and the other end passes through an existing bearing in this base. Dynamic load is developed by vibrating the mass block *c* between a pair of springs *d*, which are compressed initially between the head *e* and a collar *f*, integral with the rod *b*, so that each remains under compression at the largest displacement of the mass block *c* from its mean position. The block *c* is supported and guided by a pair of rocking plates *r*, which extend across the width of the block and are attached at their tops to the block *c*, and at their bases to the machine frame *l*, by cross-strip pivots *t*. Vibration of the mass block *c* between the springs *d* is excited through a connecting rod *m* by an adjustable eccentric *n*, driven by a motor *o*. The connecting rod is a light tubular steel member housing at its big-end a 5-in. outside diameter single-row deep-grooved steel-caged ball bearing; in place of the conventional little-end bearing, a flexible link is used to render the connecting rod proper virtually integral with a "piston" rod. The latter passes through a bearing on the machine base and then through a friction clutch *p* rigidly mounted on the mass block *c*. The clutch, shown diagrammatically in Fig. 5b, consists simply of two pieces of fabric-filled laminated plastic, clamped on the piston rod by spring pressure, adjustable by means of the wing nuts *q*. In order to prevent the flexible link between the connecting and piston rods from being overloaded in compression, this link is initially loaded in tension by means of a light spring interposed between a collar on the piston rod, and a stop on the machine base. This spring also serves to take up partially the slight play in the big-end bearing.

Static load is applied by means of a pair of springs *g*, mounted on a sleeve *h*, one on each side of the rear boss on the machine base *l*; the sleeve is free to slide through this boss, and static load is imposed by tightening nut *j* for tension, or *k* for compression.

VARIABLE-THROW DRIVE

The machine may be operated by means of the slipping clutch. In that case the throw of the eccentric drive would be preset, and means need be provided to vary the throw only when the machine is at rest.

However, in order to attain a high range of load smoothly, it would certainly be desirable to provide a separately operable mechanism for engaging the clutch when the running speed has been attained. Therefore, in the present prototype machine it has been considered preferable to retain the simple preset clutch, and to devise

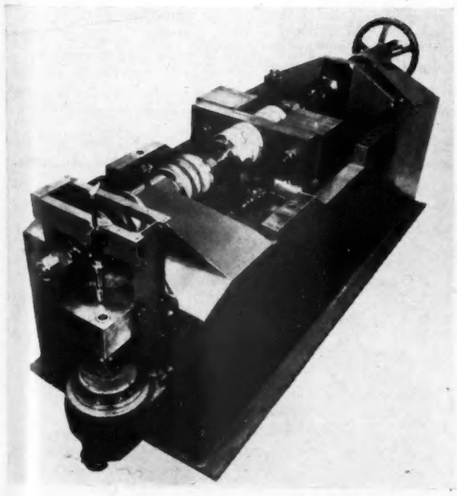

Fig. 3 Prototype of 10-ton slipping-clutch fatigue-testing machine seen from the driving end.

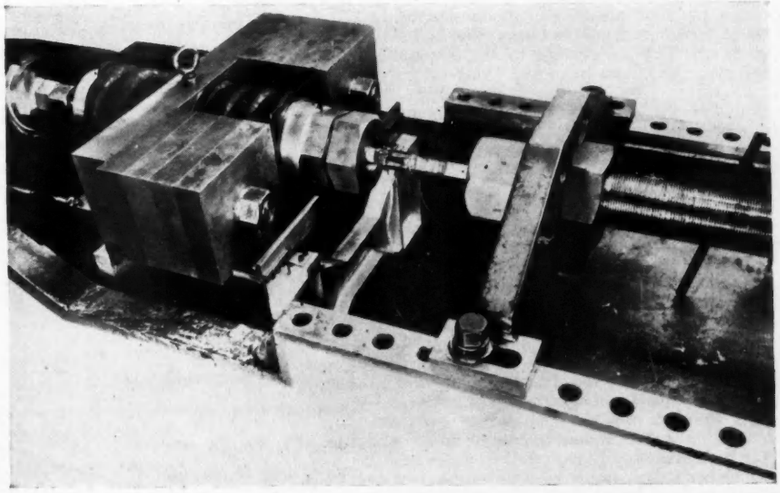

Fig. 4 The test-piece is loaded for fatigue by a [mass (towards the left of the illustration which is caused to oscillate between springs at resonant frequency.

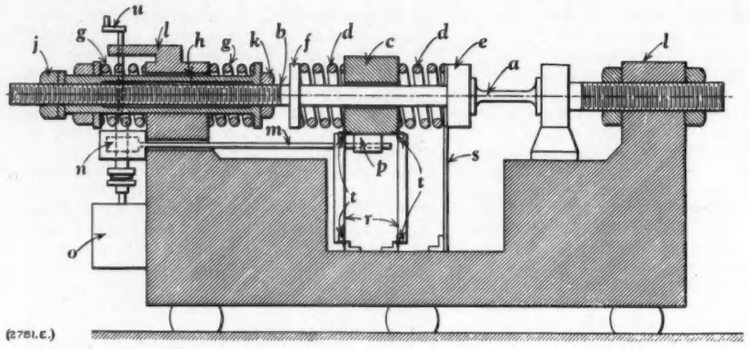

Fig. 5a Arrangement of prototype machine.

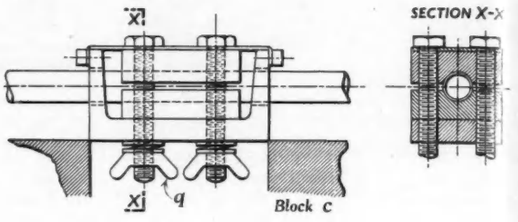

Fig. 5b (above) Slipping clutch on main drive.

means to vary the throw of the eccentric while it is actually rotating. With this the motor drive may be run up to operating speed with the throw set at, or close to, zero, and thereafter the amplitude may be raised to any desired value by increasing the throw of the eccentric. By this method even the simple clutch is rendered unnecessary, but it is in fact retained to act as a "breaking link," which operates a trip switch and shuts down the machine if for any reason the oscillatory system falls out of resonance.

The arrangement of the variable-throw eccentric is shown in Fig. 6a. The tubular driving shaft is supported in two ball bearings mounted in plates attached to the machine base. Between these bearings two lateral slots are machined on opposite sides of the shaft; the centre parts of these slots are deep enough to penetrate the inner wall of the tube, while at the sides of each slot a narrow ledge is left. The eccentric sheave is mounted over two cheeks which fit in the slots and rest on the ledges, so that the sheave as a whole is slidable transversely across the driving shaft. The centre parts of the cheeks between these sliding surfaces project through the deeper slot, and so into the bore of the tube. On the faces of these projecting lands, racks are machined with their axes inclined at 1 in 10 to the axis of the tube; these racks engage with similar racks cut along the sides of an internal member, so that by sliding this member along the bore of the outer tube, the eccentric sheave may be moved transversely across the driving shaft. In order to take up backlash, and to provide a positive lock, the internal member is made in two halves, divided by the diametral plane between the two racks; the two halves are forced apart along the axis of the shaft by an internal spring, so that the racks on their sides, in mesh with those on the inside of the eccentric sheave, are locked one against the other. One end of each half projects beyond the end of the driving shaft, and there terminates in two collars between which a third collar is loosely held between thrust races. This loose collar is held from rotation by attachment to the operating screw by which it can be moved along the axis of the drive. The scheme of the system is indicated in Fig. 6b; it will be seen there how operation of the screw by exerting pressure on one thrust race or the other serves to unlock the two racks.

OPERATION

The driving shaft is driven at about 2,000 r.p.m. by a 1-h.p. direct-current motor, through an ordinary pin and disc coupling; but since it is desirable to maintain tight coupling between the driving motor and the oscillatory system, the disc is of thin steel and the pins are well fitted. If this connection were not torsionally stiff, or if it exhibited backlash, the reaction of the oscillatory system on the driving motor would be impaired, and it would probably be necessary to run with the motor "overdriving" so that the slack in the drive should be entirely taken up.

The measurement of load range in the present machine is effected simply by observation of the amplitude of vibration of the mass block (*c* in Fig. 5a) by means of a Föppl wedge mounted on the block and calibrated by means of a weighbar fitted with electrical resistance strain gauges. A representative calibration curve thus obtained is shown in Fig. 9.

In addition to the trip switch which shuts down the machine if the clutch should slip, another is fitted to stop the motor when the test-piece breaks. This cut-out, situated between the rod *b* and the base *f*, is adjusted by a fine screw, and the machine normally stops before the fatigue crack has advanced far; on several occasions the crack has not been found until after the machine has been restarted with the cut-out more coarsely set.

ENDURANCE TEST

The prototype machine was constructed during 1951 and it was ready for continuous service early in 1952. Since February, 1952, it has completed over 650 million cycles, mostly of ranges from 6 to 8 tons. Since the machine does about 3 million cycles a day, this represents about 35 per cent. of continuous running; but during this time the machine has stood idle for several periods while minor adjustments were made, and in the last six weeks of the period over 80 million cycles have been completed. This factor of use—about 70 per cent.—approaches that normally attained with fatigue testing equipment, and the idle time of 20 to

TABLE 1.—MATERIAL RECEIVED DIRECT FROM MAKER.
Results of Fatigue Tests on 1 in. dia. Short-Link Wrought-Iron Chain.

Test mark	Load range tons	Estimated stress range tons per sq. in.	Endurance × 10^6 cycles	Position of fracture
TWH 1F11	12·5	39·4	0·190 B*	Intrados, unforged end
,, 1F1	11·7	36·2	0·312 B*	,, ,, ,,
,, 1F2	10·4	31·8	0·165 B	,, forged end
,, 1F3	9·1	29·0	0·589 B	,, unforged end
,, 1F4	8·3	25·4	0·786 B	,, ,, ,,
,, 1F5	8·3	26·8	0·874 B	,, ,, ,,
,, 1F6	7·8	23·8	0·991 B	,, ,, ,,
,, 1F1	7·8	24·0	11·904 U	Unbroken
,, 1F7	7·3	23·0	0·566 B	Intrados, unforged end
,, 1F8	7·3	24·4	0·663 B	,, ,, ,,
,, 1F10	6·8	21·1	1·726 B	,, ,, ,,
,, 1F9	6·8	21·1	1·934 B	Centre of side length
,, 1F12	6·5	20·0	12·625 U	Unbroken
,, 1F11	6·2	19·7	16·786 U	Unbroken

TABLE 2.—MATERIAL RECEIVED DIRECT FROM MAKER, NORMALISED AT 950 DEG. C., RUMBLED FOR 6 HOURS, AND AGED AT 100 DEG. C. FOR 24 HOURS.
Results of Fatigue Tests on 1 in. dia. Short-Link Wrought-Iron Chain.

Test mark	Load range tons	Estimated stress range tons per sq. in.	Endurance × 10^6 cycles	Position of fracture
TWH 2F3	11·3	34·6	0·124 B*	Intrados
,, 2F5	9·8	31·0	0·284 B*	,,
,, 2F1	9·0	28·0	1·148 B*	,,
,, 2F4	8·4	26·2	2·631 B	,,
,, 2F2	7·8	25·8	0·536 B	,,
,, 2F3	7·8	23·8	13·980 U	Unbroken
,, 2F5	7·8	24·6	21·000 U	,,
,, 2F1	7·0	21·8	11·753 U	,,

* Results so marked were second tests on pieces which had survived a previous test at a lower load.
B = broken. U = unbroken.

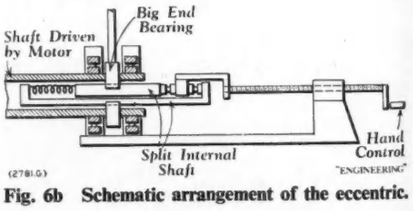

Fig. 6b Schematic arrangement of the eccentric.

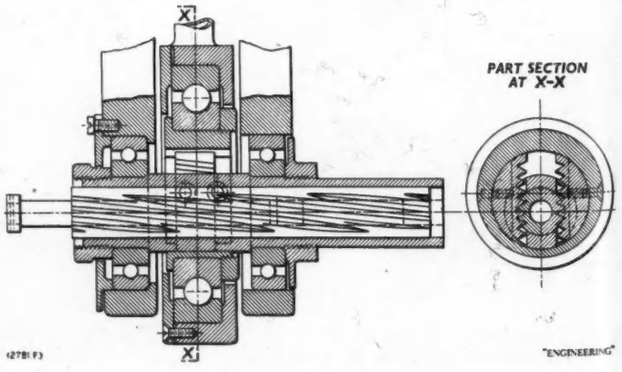

Fig. 6a Arrangement of variable-throw eccentric. By this, the amplitude can be altered while the machine is in operation.

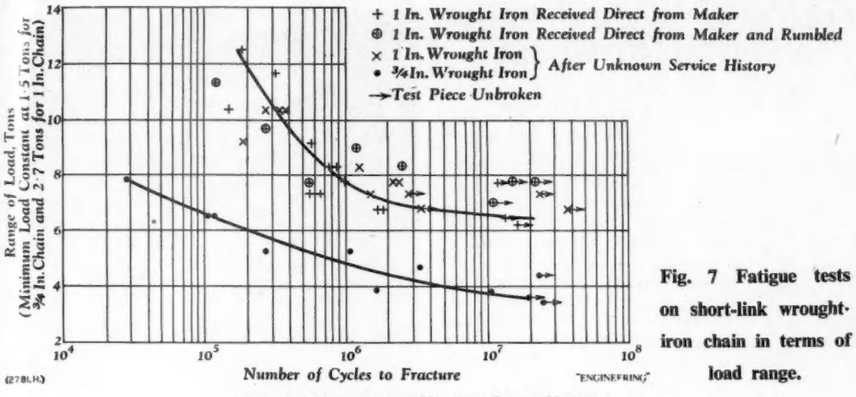
+ 1 In. Wrought Iron Received Direct from Maker
⊕ 1 In. Wrought Iron Received Direct from Maker and Rumbled
× 1 In. Wrought Iron
• ¾ In. Wrought Iron
After Unknown Service History
→ Test Piece Unbroken
Range of Load, Tons (Minimum Load Constant at 1·5 Tons for ¾ In. Chain and 2·7 Tons for 1 In. Chain)
Number of Cycles to Fracture
"ENGINEERING"

Fig. 7 Fatigue tests on short-link wrought-iron chain in terms of load range.

TABLE 3.—MATERIAL AFTER UNKNOWN SERVICE HISTORY.
Results of Fatigue Tests on 1 in. dia. Short-Link Wrought-Iron Chain.

Test mark	Load range tons	Estimated stress range tons per sq. in.	Endurance × 10^6 cycles	Position of fracture
TQC 1F6	10·4	31·4	0·286 B*	Intrados, unforged end
,, 1F7	10·4	31·4	0·346 B	,, ,, ,,
,, 1F3	10·4	31·4	0·361 B*	,, ,, ,,
,, 1F4	9·1	27·2	0·198 B	Extrados, forged end
,, 1F1	8·3	24·8	1·169 B	Intrados, unforged end
,, 1F8	7·8	22·9	2·106 B*	Extrados, forged end
,, 1F2	7·8	24·6	2·142 B	Intrados, unforged end
,, 1F5	7·3	22·4	1·510 B	,, ,, ,,
,, 1F8	7·3	21·3	2·817 U*	Unbroken
,, 1F6	7·3	22·1	23·774 U	,,
,, 1F8	6·8	20·0	3·293 U	,,
,, 1F3	6·8	20·6	37·866 U	,,

TABLE 4.—MATERIAL AFTER UNKNOWN SERVICE HISTORY.
Results of Fatigue Tests on ¾ inch dia. Short Link Wrought Iron Chain.

Test mark	Load range tons	Estimated stress range tons per sq. in.	Endurance × 10^6 cycles	Position of fracture
TQC 2F1	7·8	43·7	0·029 B	Extrados, forged end
,, 2F2	6·5	36·2	0·110 B	,, ,, ,,
,, 2F10	6·5	36·2	0·110 B*	,, ,, ,,
,, 2F3	5·2	28·9	0·275 B	,, ,, ,,
,, 2F6	5·2	28·9	1·016 B	,, ,, ,,
,, 2F7	4·7	26·2	3·187 B	Intrados, forged end
,, 2F5	4·4	24·6	21·773 U	Unbroken
,, 2F8	3·9	21·8	1·774 B	Extrados, forged end
,, 2F4	3·9	21·8	10·051 B	,, ,, ,,
,, 2F10	3·65	20·4	19·718 U	Unbroken
,, 2F9	3·4	18·9	25·863 U	,,

* Results so marked were second tests on pieces which had survived a previous test at a lower load.
B = broken. U = unbroken.

30 per cent. is occasioned chiefly by breakages of test-pieces and fitting of new ones.

As implied above, the endurance test has been run, not on a calibration test bar, but on actual test-pieces. It was considered preferable to try out the machine under actual working conditions so that the test should cover all aspects of operation, including the reliability of load control and of cut-outs. Moreover, in view of the present paucity of fatigue testing equipment it seemed a pity to "waste" 650 million cycles or so, although at the same time it was clearly out of the question immediately to allocate to the untried machine any part of the main programme of tests in progress at Mechanical Engineering Research Laboratory. Fortunately, it happened most opportunely that a need arose for some further information on the fatigue resistance of crane chain, in relation to changes of practice which are now becoming stabilised in that field. This type of test-piece was almost ideal for three reasons; first, it is virtually self-aligning, so that close alignment of the machine grips themselves is not essential; second, the stiffness of four or five links of chain is low, so that the insensitivity of the machine to stiffness of test-piece would be put to a thorough test; and third, the variation from one test-piece to another, even in machine-made chain, is such that it would be ridiculous to attempt to assess fatigue resistance to an accuracy closer than 5 per cent. From the outset there was no doubt that the new machine would fulfil this low standard.

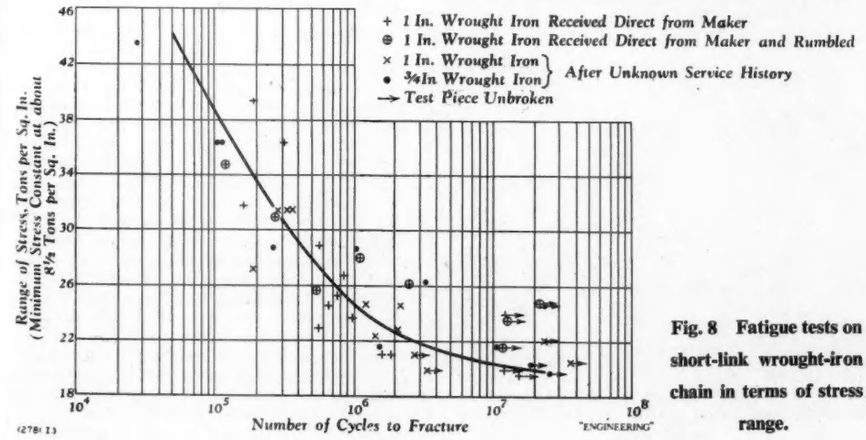
+ 1 In. Wrought Iron Received Direct from Maker
⊕ 1 In. Wrought Iron Received Direct from Maker and Rumbled
× 1 In. Wrought Iron
• ⅞ In Wrought Iron
After Unknown Service History
→ Test Piece Unbroken
Range of Stress, Tons per Sq. In. (Minimum Stress Constant at about 8⅓ Tons per Sq. In.)
Number of Cycles to Fracture
"ENGINEERING"

Fig. 8 Fatigue tests on short-link wrought-iron chain in terms of stress range.

The results of tests on a representative range of crane chain, in sizes from ¾ in. to 1 in., hold a considerable intrinsic interest in demonstrating the insensitivity of fatigue resistance to metallurgical faults, which markedly affect other qualities of the chain. However, a selection from the results so far obtained is shown in Tables 1 to 4 and Figs. 7 and 8 only to illustrate the performance of the testing machine. The scatter of the results about the mean S-N curves is no greater than usual, and indeed is somewhat less than would be expected on account of the variations of geometry of the test-pieces. On the basis of these results, supplemented by separate calibration tests, the operation of the machine is considered entirely satisfactory.

FUTURE DEVELOPMENT

The general layout of the prototype machine was largely dictated by the shape of the existing Schenck base, and in a machine designed as a whole certain slight changes would be made. The arrangement of range and mean-load springs in tandem on a single rod is not very convenient, and the guiding of that rod through a bearing in the machine base is not satisfactory; unless the fit is fairly close, alignment is not preserved, and with even moderately close fit serious fretting corrosion results from the small relative axial movement in this bearing. In a new machine full parallel motion on cross strip-pivots would be adopted for the moving test-piece head, and complete clearance would be left at all parts subject to small relative movement. The railway drawsprings used in the prototype have exceeded 300 million cycles and proved their suitability for load ranges up to about 10 tons; for lengthy runs exceeding this range, spring failures would be more frequent, but, even so, since the springs are relatively inexpensive, it would be reasonable to cater for occasional failures by making their replacement easier than in the present design.

In a new machine the drive would be arranged on the centre line so as to obviate any risk of exciting transverse or rotational movement of the mass block, which has been observed when the parallel movement on the plates *r* has been ill-adjusted. Otherwise the drive appears satisfactory, except that the slack inherent in the big-end bearing, and to some extent also in the mounting of the eccentric and driving shaft, sometimes permits too great a variation of amplitude. This point is the final limitation on the accuracy of control, and other means to reduce the slack are being considered. However, provided that the throw of the eccentric is made

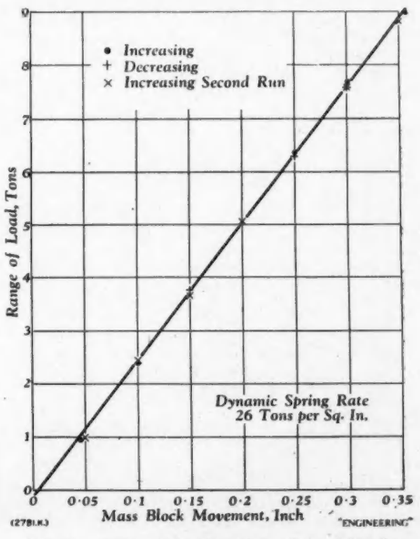

Fig. 9 Dynamic calibration of machine in tension.

moderately great (about ½ in.) at full range, the uncertainty of control due to slack may be kept below ± 2 per cent. at full-load range, and certainly not worse than ±5 per cent. at one third of full range. These variations result from "overthrowing" or "underthrowing" against the slack, according to whether the motor controls are adjusted to settings above or below that which would correspond to true resonance. The machine at present is running without any stabiliser at all, direct on a nominal 110-volt direct-current circuit. This circuit is rather lightly loaded, and the actual voltage varies widely and often quite abruptly; the load control of the machine would certainly be improved by a more stable electrical supply.

Acknowledgments.—The work described above was carried out in the Physics Division of the National Physical Laboratory as part of the Research Programme of the Mechanical Engineering Research Laboratory. The article is published by permission of the Director of the National Physical Laboratory and the Director of Mechanical Engineering Research of the Department of Scientific and Industrial Research. The authors desire to acknowledge the assistance rendered by Mr. J. W. Casemore who carried out the fatigue tests.

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PHOTOELECTRIC DEVICES

Daylight monitoring equipment, a remote cell housing, and a projector incorporating an anodised aluminium reflector are three recent extensions to the range of photoelectric equipment made by the General Electric Company, Limited, Magnet House, London, W.C.2.

The daylight monitoring equipment measures continuously the amount of daylight present and when this falls below a pre-set limit the unit automatically switches on the artificial illumination. The advantage of this system of control is that it is dependent solely on the prevailing lighting conditions and therefore eliminates the possibility of lights being left on when they are no longer needed. The unit is housed in a cast aluminium weatherproof case.

The unit is equipped with a remote sensitivity control unit which can be situated up to 300 ft. away and enables the sensitivity to be varied so that the relay will operate at the required degree of daylight. The switching range is continuously variable between 0·4 and 3 lumens per square foot and the circuit is arranged so that relay "chatter" does not occur at dusk and dawn.

In some installations where photoelectric devices are used, space is limited and a complete photoelectric amplifier cannot readily be accommodated. For such applications the G.E.C. have now introduced a type of equipment in which the light-sensitive cell is housed separately from the main relay amplifier and control box. The cell housing, which can be situated up to 300 ft. from the main relay amplifier, is of cast metal construction and measures 4¼ in. high by 2¾ in. deep by 1⅝ in. wide.

The medium-range projector is suitable for a wide variety of photoelectric applications. It has a range up to 48 ft. with white light and up to 32 ft. with infra-red light. A 12-volt 24-watt small bayonet-cap line-filament lamp is used and this is housed in a robust holder designed for variable focus. The parabolic reflector, of superpurity anodised aluminium, has a three-point spring mounting which facilitates alignment.

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ELECTRICITY SCHEME FOR ISLE OF HARRIS

The Secretary of State for Scotland has confirmed a scheme, prepared by the North of Scotland Hydro-Electric Board, for the supply of electricity in the island of Harris. This will involve the construction of a dam across the River Eaval at its outlet from Loch Chliostair, about 12 miles from Tarbert, and of a pipeline through which water will be led to a 700-kW generating station with an annual output of 2,400,000 kWh.

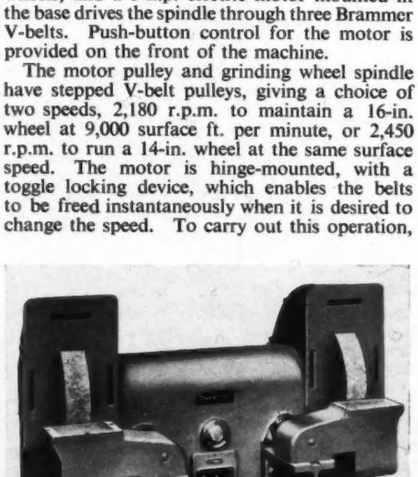
CONTROL OF DUST FROM A GRINDING WHEEL

Air Curtains Surround the Dust Zone

It is now well known that the airstream produced by the periphery of a grinding wheel rotating at high speed carries with it small particles of dust. On a pedestal grinder the airstream is deflected by the article being ground, and travels at high speed up the operator's body line into his breathing zone. Conventional dust-extraction systems, with a suction duct coupled to the wheel guard and cowl, can remove the larger dust particles, but do not control the small particles, which are highly dangerous to the human lung. A special investigation into this dust-control problem has been carried out over the last two years by the British Cast Iron Research Association, Alvechurch, near Birmingham, and they have evolved an "external dust-control" system which by means of "air-curtains", prevents the dust from escaping and draws it into the extraction plant. A manufacturing licence has been granted to Beacon Machine Tools, Limited, Hurst-lane, Tipton, Staffordshire, for the production of machines incorporating the Research Association's system, and a 16-in. double-ended grinder is now on the market. It has been designed to comply with the requirements of the Iron and Steel Foundries Regulations, 1953, which come into force on January 1, 1956.

The machine is orthodox in general appearance, except for the dust-control hoods, but incorporates a number of mechanical improvements in addition to the dust-control feature. It is carried on a heavy cast-iron cabinet-type base giving a rigid vibration-free mounting. The base is enclosed at the front and has two louvre-ventilated detachable covers at the rear for access to the motor and drive gear. A double-ended spindle mounted in angular-contact ball bearings carries the two 16-in. diameter by 3-in. wide wheels, and a 5-h.p. electric motor mounted in the base drives the spindle through three Brammer V-belts. Push-button control for the motor is provided on the front of the machine.

The motor pulley and grinding wheel spindle have stepped V-belt pulleys, giving a choice of two speeds, 2,180 r.p.m. to maintain a 16-in. wheel at 9,000 surface ft. per minute, or 2,450 r.p.m. to run a 14-in. wheel at the same surface speed. The motor is hinge-mounted, with a toggle locking device, which enables the belts to be freed instantaneously when it is desired to change the speed. To carry out this operation,



The Beacon double-ended pedestal grinder is built to a design evolved by the British Cast Iron Research Association for the effective removal of the fine dust.

A photograph taken in darkness with a high-intensity light beam shows how the air curtains withdraw the dust before it can reach the operator's breathing zone. All particles down to less than 1 micron are visible.

the motor is stopped and the rear covers are removed. The motor is then raised by using the toggle, and the spindle pulley is moved on a sliding key to its new position. The belts are then moved over, the motor is lowered and locked by the toggle, and the covers are replaced. Independent adjustment of belt tension is possible by means of an adjustable link to the motor baseplate.

A mechanical interlock is provided between the spindle pulley and the adjustable work-rests on the front of the machine. These work-rests are arranged to slide on brackets carried on the main base, and have projections passing through the base casting to engage with the interlocking levers. This arrangement ensures that the rests are moved inwards when the speed is changed to allow for wheel wear, and also ensures that when the rests are moved out again to accommodate new wheels, the speed is reduced to suit the wheels. The work-rests are of malleable cast iron, with renewable Meehanite pads, each of which has 240 holes drilled in it for the passage of heavy dust and particles. The rests are a sliding fit in the dust hoods, and dust passing through the holes is extracted by the lower of two ducts behind each wheel. Height adjustment of the work-rests is effected by means of packing pieces.

AIR CURTAIN ROUND EACH WHEEL

The dust hoods, which are of fabricated steel, act as safety guards and have, as will be seen from the general view, three slots arranged round the wheels. These slots, together with the perforated work-rests provide a complete air-curtain round the front of the wheel. Each wheel has two duct connections, one at the top, which requires to be coupled to a high-suction source, and the other at the bottom, for which a lower suction is suitable. The top duct withdraws the air from the slot over the wheel, and also, by means of two subsidiary ducts, from the two side slots. An air volume of 400 cub. ft. per minute at a minimum suction of 5½ in. water gauge is necessary for the top duct, which provides a high-velocity air curtain round the exposed part of the wheel, and ensures that all the dust which would otherwise be thrown off is withdrawn. At the lower duct, which draws off the heavier particles, an air volume of 300 cub. ft. per minute at 2½ in. water gauge minimum is required. A small test hole is provided on the top of each of the two high-suction hoods, and a manometer can be connected at any time to check the suction.

RECORDING X-RAY DIFFRACTOMETER

LABORATORY INSTRUMENT WITH MANY INDUSTRIAL APPLICATIONS

Although primarily intended for use in research work many applications have been found for this instrument in industrial laboratories. It can be used, for example, for the quantitative determination of polycrystalline substances of which it is desired to ascertain the precise amount of one or more constituents in a mixture of several. In organic chemistry and in the manufacture of plastics, the instrument is employed in the study of artificial fibres, such as Nylon, Terylene, etc., many of which behave as single crystals to X-rays so that the mechanism for detecting diffractions from the lattice planes operates three dimensionally and thus provides, relatively simply, all the information needed in the investigation of a sample of this type. Another useful industrial application is in the identification and measurement of impurities present in a sample. In work of this kind, X-ray spectra, produced from the secondary emission of radiation from the sample, are recorded on a chart and this furnishes identities and, in many cases precise percentages, of elements present as impurities. This method can thus be used for industrial control and has the advantage that it can be operated by an unskilled worker to control the quality of a particular product or raw material. Often it is not necessary to record complete diffraction patterns in this application, the desired check being achieved from a selected relatively narrow section of the record. The instrument can, in short, deal with practically every problem involving X-ray diffraction and has the particular advantage, in comparison with other methods, that its operation is practically automatic and that a quantitative answer is obtained accurately and rapidly. The latter characteristic is due mainly to the fact that the use of photography is dispensed with.

GENERAL ARRANGEMENT

The diffractometer, which is made by Hilger and Watts, Limited, Hilger Division, 98 St. Pancras-way, Camden-road, London, N.W.1, operates in the horizontal plane and the general arrangement of the principal parts can be followed from the accompanying illustration. All the mechanism is enclosed in a dust-proof rectangular casing of light alloy, the controls being mounted on one side, so as to face the operator. On the top of the casing, on the left of the illustration, is the housing for the monitoring tube, the function of which is to compensate for any variations in the radiation from the X-ray tube. At the centre is the specimen which rotates about a vertical axis. The Geiger tube detector, which measures the radiation diffracted from the specimen, is enclosed in the rectangular housing seen on the right. The housing, it will be noted, is mounted on a bracket screwed on to a circular table flush with the upper surface of the casing and rotating concentrically with the axis of the specimen holder, but at twice the angular velocity of the latter. The reason for this is that if the incident beam makes an angle θ with the surface of the specimen, the diffracted beam will leave the surface at the same angle and will therefore make an angle 2θ with the direction of the incident beam. The detector tube must therefore rotate at twice the angular velocity of the specimen holder for its axis to follow the diffracted beam. The 2 : 1 angular-velocity ratio is obtained in a simple but effective manner which does not involve the use of toothed gearing. Two steel discs of large diameter are located one above the other with three steel balls, contained in a cage, between them. The upper disc forms the table on which the detector tube is mounted and is driven at a suitable speed, the lower disc being held stationary. It will be clear that with this arrangement the cage containing the balls, which is connected to the mounting of the specimen holder, will rotate at half the angular velocity of the upper disc carrying the detector tube. The pulses produced in the latter by the diffracted beam, are applied, after suitable amplification, to a ratio-type pen recorder which gives a record in ink on a paper chart.

APPLICATION OF PRIMARY RADIATION TO SPECIMEN

The instrument should be used in conjunction with a tube having a fine X-ray focus, such as the Hilger H.R.X. unit for which it was originally designed, but it can be employed with other tubes provided that the X-ray window of the tube can be situated at a suitable height above the bench on which the diffractometer stands. In the monitoring tube part of the primary radiation is received on a piece of aluminium foil placed at such an angle to the beam that after one or more reflections from the foil the radiation is received in a Geiger monitoring tube, the electrical output from which is supplied to the ratio recorder in addition to that from the rotating detector tube previously mentioned. In this way the record is automatically corrected for variations in the operation of the X-ray tube. The remainder of the primary radiation leaves the monitoring tube housing through a horizontal collimating slit, which can be distinguished in the illustration, and reaches the specimen in its holder. Between the latter and the detector tube is a fitting carrying a rotatable β-filter holder, which enables any one of four filters to be used, and also has a vertical slit to reduce scatter; another slit is fitted on the end of the detector-tube housing. The slits, it should be noted, are fixed, but are interchangeable without affecting the alignment.

SCANNING ARRANGEMENTS

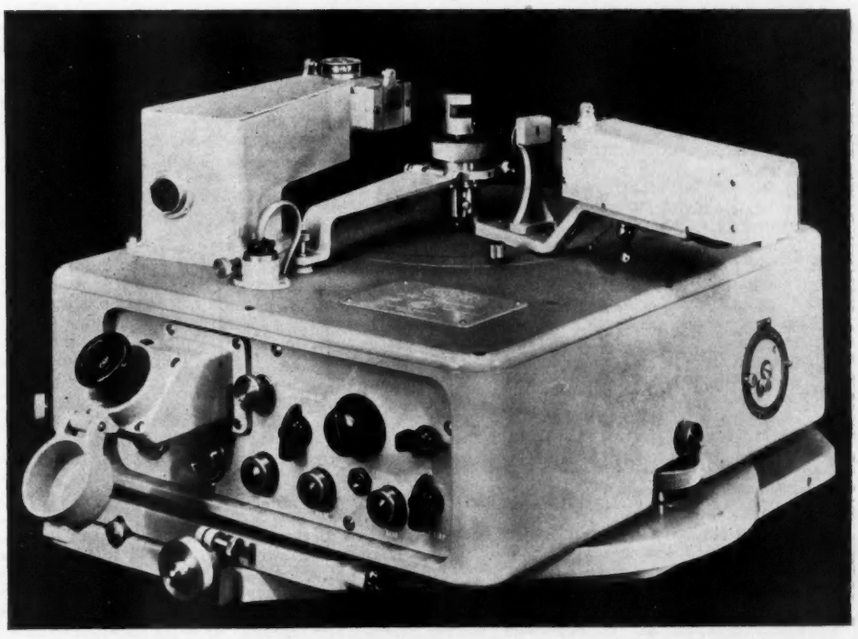
The scanning range of the instrument, that is, the angular movement of the table carrying the detector tube, is from $-$ 10 deg. to $+$ 157 deg. of the angle 2θ, and the mechanism, which is operated by a synchronous motor, gives six scanning speeds ranging from 2 deg. to $\frac{1}{10}$th deg. of 2θ per minute. The scanning can be either automatic and continuous or in steps controlled by hand. The angular position of the detector tube can be read at any time on a glass divided circle which moves with the table and is visible through an eyepiece on the left-hand side of the control panel and clearly shown in the illustration; measurements to within 0·002 deg. are possible. The mechanism provides automatic forward and reverse scanning over selected regions of the spectrum and the instrument will scan backwards and forwards over the selected region for any desired number of oscillations.

CHART RECORD

As the complete chart is 53 in. long and 11 in. wide it is impracticable to reproduce it in the space at our disposal. The record takes the form of an irregular base line on which a number of tall peaks occur at intervals, being produced, of course, by the X-rays diffracted from the lattice planes of the crystalline specimen. The heights of the peaks roughly indicate the order of intensity of the particular radiation, which may be assessed in terms of counts per minute from the Geiger detector tube. The Bragg angle θ is measured along the horizontal axis of the chart and the irregularity of the base line, previously mentioned, is due to small quantities of radiation scattered from the sample, and from the air through which the beam passes, reaching the detector tube. Some of the tall peaks on the chart are double, the doubling being caused by the separate reflections of the α_1 and α_2 components of the radiation employed; the circumstance that they do not appear on all the peaks is governed by the resolving power of the instrument. The β component of the radiation, which would greatly complicate the diffraction pattern, is eliminated by the rotatable filter mentioned earlier.

SPECIMEN HOLDERS

Each diffractometer is provided with a holder for powdered samples, the holder being centred by a Morse taper. The sample is pressed into a central hole in a glass ring and the bearing faces of the holder are accurately machined so that the compacted sample, when pressed in its holder against them, lies within 0·0005 in. of the true axis of the instrument. A block-sample holder, having the same accuracy as the powder-sample holder, is available, and with this large specimens, up to 0·75 in. in thickness, can be investigated. A spinning sample holder, which is an optional accessory, is provided with a small electric motor so that a powdered specimen can be spun rapidly on an axis at right angles to that of the instrument. This holder is particularly advantageous for the examination of heterogeneous samples, since it allows greater areas of



Recording X-ray diffractometer for identifying constituents or detecting impurities.

the specimen to be examined and thus gives a more representative result. Another special attachment, which is very suitable for the analysis of mixed or chemically-combined elements by fluorescence, may be mentioned in conclusion. This attachment enables the specimen to be placed at an angle of 35 deg. to the primary beam and as close as possible to the window of the X-ray tube. The fluorescent radiation emitted by the sample is analysed by a crystal of known lattice spacing which is supported in the normal specimen holder.

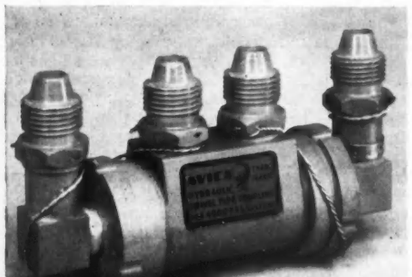
* * *

SWIVEL COUPLING FOR HYDRAULIC SYSTEMS

Flexibility at 4,000 lb. per sq. in.

When used in hydraulic systems operating at 4,000 lb. per square inch, such as are now being employed in aircraft, conventional hose loses its flexibility and faults are liable to occur at junctions. To overcome these difficulties, Avica Equipment, Limited, 1 Adams-place, George's-road, London, N.7, are developing and producing a range of swivel couplings which can give hydraulic systems as much flexibility as is obtained with hose at low pressure. One model from the range is shown in the illustration below.

These couplings retain their freedom of movement at test pressures up to 6,000 lb. per square inch (either static or pulsating) and at temperatures from −50 deg. C. to + 80 deg. C. when using hydraulic fluid. To save space and weight, the body of the coupling can be eliminated by machining the jack or ram to take the rotating shaft, its ball race, gland and retaining



A double swivel coupling from a range designed for use in high-pressure hydraulic systems.

cap nut directly. Alternatively, the body can be fixed to a bulkhead with only the rotating shaft protruding on the other side.

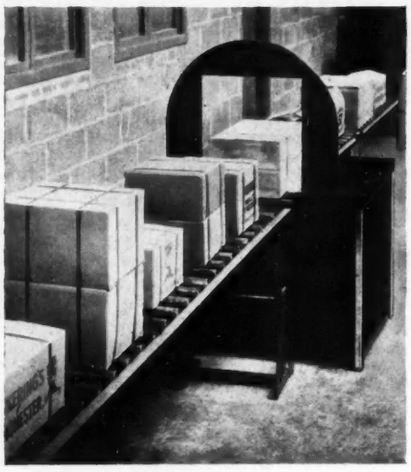
Tests show that the couplings can be used in systems with pressures as low as 50 lb. per square inch, while at the other end of the range, models are being water tested up to 20,000 lb. per square inch. At a pressure of 4,000 lb. per square inch, the torque required to turn the shaft varies from about 2 lb.-in. to a maximum of 8 lb.-in. Development is continuing to enable the couplings to be used with non-inflammable hydraulic fluids, liquid fuels for missiles and compressed gases.

* * *

STRAPPING CASES AUTOMATICALLY

Machine using flat steel banding

One of the machines shown at the recent Factory Equipment Exhibition was for strapping cases and packages with steel strip. Made by F. A. Power and Sons (Box Strapping), Limited, Birmingham, and marketed by the Package Sealing Company, Limited, 44 Uxbridge-road, Ealing, London, W.5, it is believed to be the first fully automatic machine designed to use flat banding.



Cases are pushed into the tying ring of Power and Sons' automatic strapper, and the complete operation of fitting and tying the steel strap is performed by pushing the lever forward and then pulling it back.

One is shown in the illustration above. As will be seen, the cases to be strapped have to pass through a ring and this necessarily limits the sizes that can be dealt with by any one model. That shown can deal with cases up to 20 in. wide by 21 in. high using strapping either ⅝ in. or ½ in. wide. Power is supplied by a ½-h.p. electric motor and the action is controlled by a single lever. The package is completely supported during the whole operation.

Packages are fed to the machine on a roller conveyer, the table top being also fitted with rollers. When in position, the control lever is pushed forward and the strap is drawn down from the tying ring and the preliminary tension applied. The lever is then pulled back which causes the final tension to be applied and the seal made, the latter occurring centrally beneath the package. At the same time the strap is cut off and the cut end fed round the tying ring ready for the next operation. Each tie takes only a few seconds to complete and the package is then pushed on for the next to be made. As the operator does not have to hold the package in position, fatigue is considerably reduced.

The actual tension applied to the strapping material can be preset as desired. There is, however, a compensating device which adjusts the tightness of the strap according to the rigidity of the packages. Thus, cartons coming along the conveyor line among wooden boxes would be safely strapped without fear of crushing or cutting in the corners.

SEPARATE SEALING STRIP

No prefabricated seals are used, but the machine forms its own seal from a separate coil of galvanised strip which is housed within the casing, each coil containing approximately 6,000 seals. The ends of the strap are secured by the pre-formed seal made by folding the seal strip and pressure-notching it and the overlapping sections of band strap. The banding is cut flush with the seal on the outside and the result is a smooth and flat seal with no sharp edges or irregularities, thus providing easy handling and stacking of the packages. The knot strength averages 80 per cent of that of the band strap; this is ample fulfilment of the B.S. requirements of "not less than 65 per cent., normally 75 per cent."

Band strapping for use with the machine is in large traverse-wound coils held in a container which is an integral part of the machine. It feeds the banding smoothly and easily to the tying head and refilling with a fresh coil takes only a few seconds. It is claimed that in actual operation the banding machine straps at five to six times the speed of any hand-operated tool, and is designed to handle with equal efficiency all types of wooden boxes, crates, cartons, etc. Maintenance has been reduced to a minimum, and the front and top covers can be removed in a few seconds to facilitate interior cleaning and oiling. The mechanism runs in an oil bath and the machine is also fitted with a lubricating pump, carrying oil to all of the major working parts.

* * *

SCHOOL OF ELECTRONICS

The Automatic Telephone and Electric Company, Limited, Strowger Works, Liverpool, have decided to form a School of Electronics to meet their need for more engineers in the research, development, design and production branches of their organisation. University graduates and others, having the required qualifications and potentialities, will be selected to undergo a full-time course giving both fundamental and specialist knowledge in electronics, communication engineering and also electrical measurements and materials.

The school will be organised on university lines and the duration of the course for graduate students is expected to be one academic year. During periods when the school is closed, students will carry out appropriate studies or practical work at the firm's establishments. A salary will be paid during the course and at its conclusion successful students will be offered posts according to their aptitudes and, if possible, their preference.

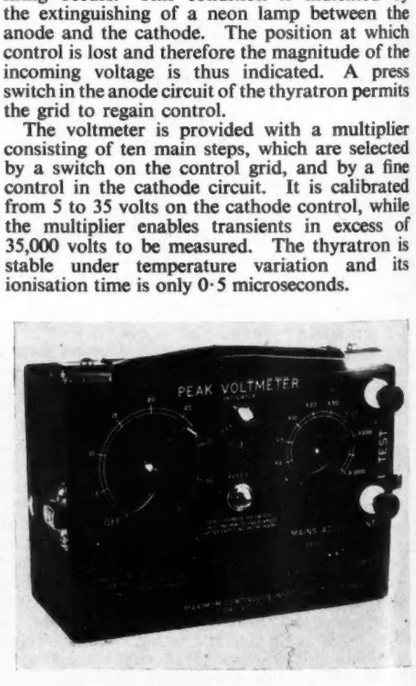
* * *

MEASURING TRANSIENT VOLTAGES

The accompanying illustration shows a portable instrument, which has been designed by Oliver Pell Control Limited, Cambridge-row, Woolwich, London, S.E.18, for measuring transient voltages from 5 to 35,000 volts with an accuracy of about 10 per cent.

It consists of a non-inductive potentiometer, across which the incoming transient voltage is connected, and of a thyratron, the control grid of which can be moved up the network until firing occurs. This condition is indicated by the extinguishing of a neon lamp between the anode and the cathode. The position at which control is lost and therefore the magnitude of the incoming voltage is thus indicated. A press switch in the anode circuit of the thyratron permits the grid to regain control.

The voltmeter is provided with a multiplier consisting of ten main steps, which are selected by a switch on the control grid, and by a fine control in the cathode circuit. It is calibrated from 5 to 35 volts on the cathode control, while the multiplier enables transients in excess of 35,000 volts to be measured. The thyratron is stable under temperature variation and its ionisation time is only 0·5 microseconds.



The Oliver Pell voltmeter for measuring transients from 5 to 35,000 volts.

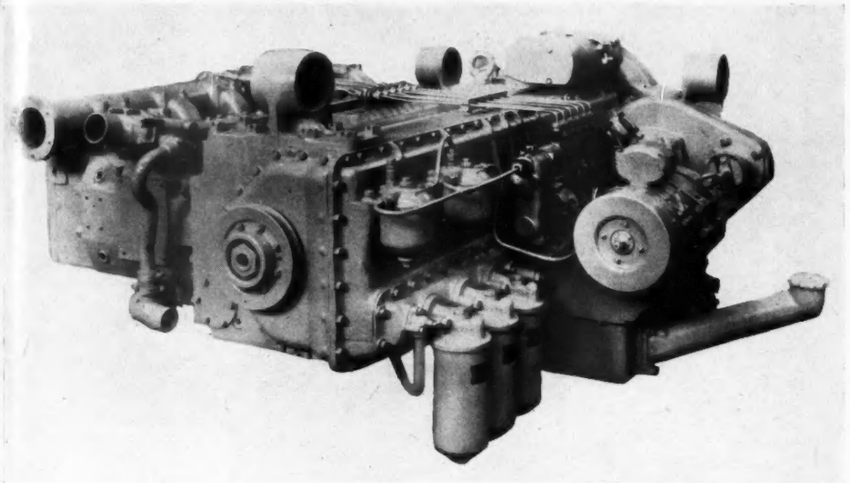


Fig. 1 The 6HDT970 six-cylinder engine develops 165 b.h.p. at 1,800 r.p.m., normally aspirated as shown here, or 240 b.h.p. when supercharged. There are no belt drives.

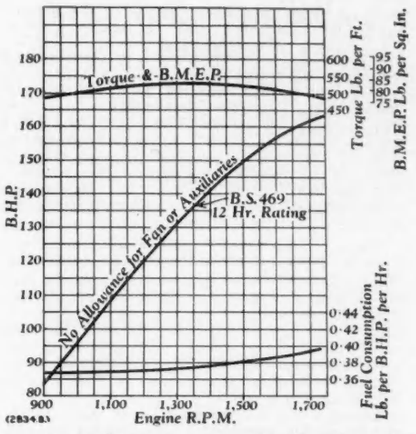


Fig. 2 Performance curves for the normally-aspirated version of the 6HDT970 engine.

HORIZONTAL DIESEL ENGINES

MODELS FOR ROAD AND RAIL TRACTION

During a recent visit to the works of Henry Meadows, Limited, at Wolverhampton, demonstrations were given of two horizontal Diesel engines which have been developed for traction purposes. These were the 6HDT970 and the 4HDC330, which are rated, normally aspirated, at 165 brake horse-power and 85 brake horse-power, respectively. Several of the engines made by this firm have previously been described in these pages.

The larger engine is primarily intended for rail-traction applications. It is a six-cylinder model, with bore and stroke of 150 mm. At 1,800 r.p.m. it develops 165 brake horse-power when normally aspirated; this can be increased to 240 brake horse-power by supercharging. The majority of the parts are interchangeable with those of the vertical GDT970 engine which was described in ENGINEERING, vol. 169, page 592 (1950). The new horizontal version is shown in Fig. 1 and its performance curves in Fig. 2. Overall dimensions are 64 in. long, 68½ in. wide and 31 in. deep for the normally-aspirated engine, these being increased to 77½ in. by 73 in. by 31 in. when the turbo-charger is fitted. The weights are 3,808 lb. and 4,108 lb., respectively.

Both crankcase and cylinder block are of cast iron, the latter being cast in two parts of three cylinders each. The cast-iron cylinder head is similarly divided. Two inlet and two exhaust valves are fitted to each cylinder, one inlet valve being masked to improve air swirl. The nitrided crankshaft runs in seven bearings 4¼ in. in diameter and the crankpins are 4 in. in diameter. The big ends are split at an angle to permit the connecting rod to be removed through the cylinder bore. Wet cast-iron liners are used. A centrifugal governor is used to control the engine speed, and this also incorporates the firm's patent mechanism for altering the injection time according to speed. In the demonstration, the engine was run at speeds between 600 r.p.m. and 1,800 r.p.m., the changes being made both in definite steps and in a single stage. The response was quick, exhaust colour scarcely changed, and the smoothness of running was not appreciably altered. There are no belt drives in this engine which conforms to Meadows usual practice of driving all auxiliaries, including camshaft, water pump and fuel pump through gears from the flywheel end. The oil pump is driven from the main timing train.

The second, and smaller, of the two engines that were particularly demonstrated during the visit, was the 4HDC330, a four-cylinder engine for automotive work. It is illustrated in Fig. 3 and the performance curves are given in Fig. 4. This engine has a bore and stroke of 120 mm. giving a maximum output of 85 brake horse-power at 2,200 r.p.m. The overall dimensions are: 50 in. wide by 39½ in. long by 24½ in. deep. The weight, including flywheel, is 1,100 lb. Most parts of this engine are interchangeable with those of the vertical 4DJ330 which was described in ENGINEERING, vol. 170, page 254 (1950).

General construction follows the lines of the 6HDT970, but in the four-cylinder engine the fuel pump is mounted on top to avoid dust and mud. As the mounting of the engine is horizontal, it has been possible to omit secondary balancing shafts, which are normally included in Meadows four-cylinder engines. This results in a reduction of cost. Fan, dynamo and exhauster (if fitted) are belt driven and the cooling water flow is controlled by a bellows-type thermostat. The engine is arranged for electric starting, as also is the six-cylinder model.

During the tour round the works, the assembly of other engines was also shown. As far as possible, flow methods are employed, using a central track with side stations. The works are fully equipped for gear cutting, heat treatment and all general machining operations. One of the units in production is a complete 27½-kVA generating set which is being made on an assembly line at the rate of about 15 a week, though this figure could be doubled if needed. The engine driving the set is the 4DJ420 which develops 66 brake horse-power and can run at either 1,500 r.p.m. or 1,800 r.p.m. to generate power at either 50 cycles or 60 cycles, as required. The full output can be obtained at altitudes up to 5,000 ft. and ambient temperatures of 125 deg. F. Four methods of starting are fitted: compressed air, cartridge, ether and hand crank. The unit is built on skids and is normally mounted on a trailer.

When delivered to the Ministry of Supply, these units are cocooned before leaving the works. As, in addition, the interior of the engine is treated with an inhibitor, the units can then remain in perfect condition for several years. The cocoon encasing the units is built up of several layers. The units stand on a sheet of plastics and are covered with a fine net, the edges of the sheet and the net being glued together. Two layers of a plastics emulsion are then sprayed over the net, followed by two layers of bitumen. To cover the whole and to reduce heat absorption, a layer of aluminium paint is then applied. Within the cocoon is a hygrometer, which can be viewed through a glass window, and also a quantity of silica gel to maintain the humidity within the limits required by the Ministry.

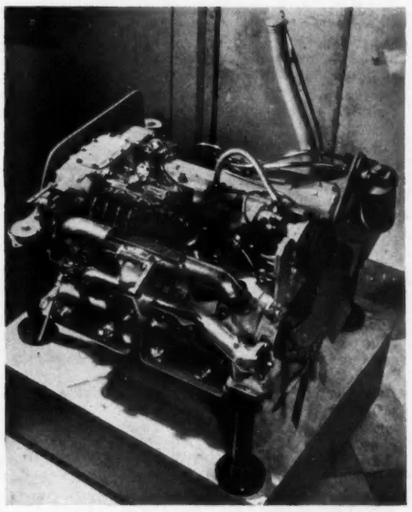


Fig. 3 The four-cylinder 4HDC330 develops 85 b.h.p. at 2,200 r.p.m. It weighs 1,100 lb.

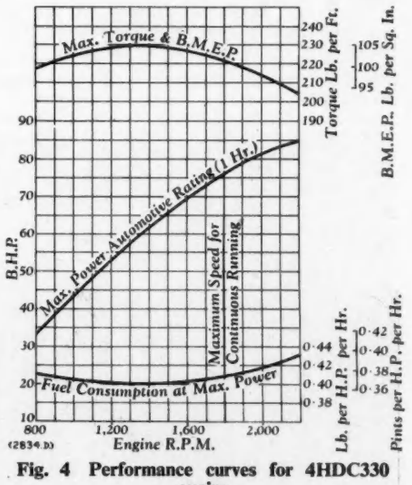


Fig. 4 Performance curves for 4HDC330 engine.

LAUNCHES AND TRIAL TRIPS

H.M.S. "KINGSFORD."—Seaward defence boat, built by the Rowhedge Ironworks Co., Ltd., Rowhedge, Essex, for the Admiralty, London, S.W.1. Length, 117 ft. 3 in. overall; beam 20 ft. Armament includes small guns, depth charges and electronic equipment. Propelled by Diesel engines, vessels of this class are designed to detect and destroy submarines, including those of the midget type. Launch, March 24.

M.S. "CHRISTINA PEZAS."—Single-screw vessel for carrying vegetable oil and general cargo, built by Short Brothers, Ltd., Sunderland, for A. K. Pezas and Transolas Compagnia Naviera S.A., Panama. Main dimensions: 438 ft. 2 in. between perpendiculars by 59 ft. 9 in. by 38 ft. 2 in. to shelter deck; deadweight capacity, about 11,480 tons on a mean summer draught of 28 ft. 9½ in. Six-cylinder single-acting two-stroke opposed-piston Diesel engine developing 4,400 b.h.p. at 115 r.p.m. in service, constructed by Harland and Wolff, Ltd., Belfast, and installed by the North Eastern Marine Engineering Co. (1938), Ltd., South Dock Engine Works, Sunderland. Trial trip, March 24.

M.S. "VINDAFJORD."—Single-screw vessel for use as a combined ore-carrier and oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for Skibs A/S Malmtransport, Oslo, Norway. Main dimensions: 489 ft. overall by 59 ft. by 35 ft. 6 in.; deadweight capacity, 12,360 tons on a draught of 27 ft. 9 in. Götaverken seven-cylinder single-acting two-stroke Diesel engine, developing 5,050 b.h.p. at 112 r.p.m. Speed, about 13¼ knots fully loaded. Delivered, March 24.

M.S. "NIKE."—Single-screw oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, for the Rederiaktiebolaget Tankoil, Gothenburg, Sweden. Main dimensions: 593 ft. 6 in. by 74 ft. 6 in. by 42 ft. 3 in.; deadweight capacity, about 23,500 tons on a draught of 32 ft. 4 in. Götaverken nine-cylinder single-acting two-stroke Diesel engine, developing 8,200 b.h.p. at 112 r.p.m. Speed, 15 knots fully loaded. Launch, March 29.

M.S. "FERNVALLEY."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Alexander Stephen & Sons, Ltd., Glasgow, for the joint West African service of Fearnley and Eger, Oslo, Norway; Det Bergenske Dampskibsselskab, Bergen, Norway; and Rederi A/B Transatlantic, Gothenburg, Sweden. Main dimensions: 400 ft. by 57 ft. by 35 ft.; gross tonnage, about 4,550; deadweight capacity, about 6,530 tons on a draught of 23 ft. Stephen-Doxford four-cylinder two-stroke opposed-piston oil engine. Trial trip, March 31.

M.S. "VIGRAFJORD."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for Skibs A/S Malmtransport, Oslo, Norway. Main dimensions: 450 ft. between perpendiculars by 61 ft. by 38 ft. 8 in.; deadweight capacity, 10,100 tons. Kincaid-Burmeister and Wain-Harland and Wolff five-cylinder two-stroke opposed-piston oil engine, developing 5,500 b.h.p. at about 112 r.p.m. in service, constructed by John G. Kincaid & Co., Ltd., Greenock. Launch, April 4.

FLOATING DOCK.—All-welded off-shore floating dock, built by John Lewis & Sons, Ltd., Aberdeen, to the order of the Aberdeen Harbour Commissioners, for installation at Albert Quay, Aberdeen. Main dimensions: 180 ft. overall by 42 ft. 6 in. by 7 ft. 6 in. (depth of pontoon); height of side wall, 29 ft. 6 in.; lifting capacity, 700 tons. Dock is capable of being sunk so as to give a depth over the keel blocks of 16 ft. Launch, April 7.

To keep the width of the trailer to the regulation 8 ft., and to make end loading practicable, twin bogies, each of four wheels, have been mounted at the rear and made removable.

ROAD TRANSPORT FOR SPECIAL LOADS

50-TON SEMI-TRAILER WITH REMOVABLE BOGIES

To meet the increasing demands for transport of heavy items such as public-works machinery or transformers by road, R. A. Dyson and Company, Limited, 76-80 Grafton-street, Liverpool, 8, have added a 50-ton semi-trailer to their present range. The load-carrying platform of this K-type unit measures 20 ft. by 8 ft. and has a loading level of 2 ft. 3 in. The overall length is 41 ft. 7 in.

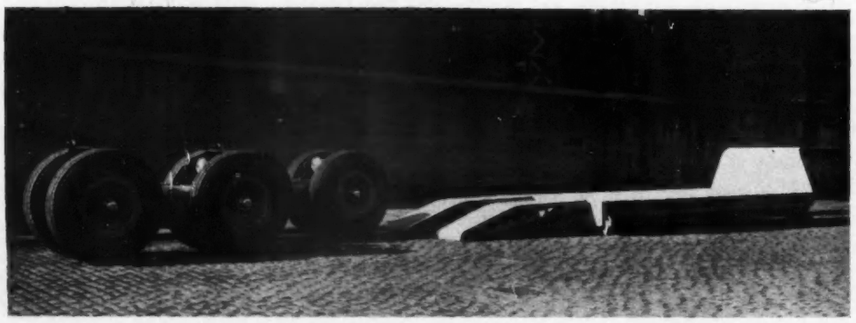
As it was required to restrict the overall width to the regulation 8 ft., the wheels were mounted at the rear in the form of two bogies, as may be seen in the illustrations. To facilitate end-loading of the platform, it was therefore necessary to make the bogie units quickly and easily removable and, with the method adopted, the trailer can be ready for loading, with ramps in position, in less than 15 minutes. The lower illustration shows the bogies dismantled and the trailer lowered to road level for loading.

Each bogie is of the "walking-beam" type and is fitted with oscillating cross-axles to ensure balanced axle loadings under all conditions. Dunlop 14·00 by 24 18-ply tyres are used, and all wheels are fitted with Girling brakes. These are operated by an air-over-hydraulic system which incorporates the Clayton-Dewandre 2-line air-pressure system. In addition, a hand brake is fitted to each bogie which applies a hydraulic lock on each line of rear wheels. The operating hand-wheels for this can be seen in the top illustration, projecting backwards between the rear pairs of wheels.

The bogie units are attached to the main frame by a device which consists basically of a withdrawable composite rocker pin. Built into the rocker beam are guide plates which locate the frame housing as the bogie is run over the main beam, bringing the bores for the rocker pin to within $\frac{1}{16}$ in. of alignment. The rocker beam is a box-section structure made in the form of an inverted U. At each end are bearing pins which carry the axle assemblies. The main rocker pin is hollow and carries within it a second pin, screwed at one end and fitted with a hand-wheel at the other, by which it may be withdrawn. This hand-wheel can also be seen in the illustration above, projecting from the side of the rocker beam on a level with the axles. The main rocker pin is tapered on the outside to facilitate insertion, making the rough alignment given by the guide plates sufficient for this. The taper also reduces the distance the pin has to be screwed out before it becomes free.

When the bogies are to be removed, the weight of the trailer is taken on the jacks at the rear of the platform, as illustrated below. The spring-loaded locking lever is then moved to release the catch which prevents the rocker pin from moving, and the hand-wheel is unscrewed a few turns. This unscrews the inner pin until a collar on it engages with the main pin. Continued turning of the hand-wheel then withdraws the main pin and eventually screws it right out. A spring holds the two pins together when they are withdrawn. The bogies can then be pushed clear of the trailer, the latter lowered on the jacks, and the loading ramps placed in position. This is the position shown in the lower illustration. The hole from which the rocker pin has been withdrawn can be seen on the nearer bogie. To replace the bogies, the process is reversed. A waterproof canvas cover shields the mechanism from dirt or grit.

The trailer also has a ramping ledge for side loading when this is required. To allow movement over rough ground, the bogies have an articulation of 7 in. up and down, enabling a 14-in. obstacle to be surmounted. Transverse oscillation of the wheels is restricted to 11 deg. each way. A forecarriage is available to convert the unit to a full drawbar-type trailer.



To release each bogie, a rocker pin is withdrawn by manipulating a hand-wheel; the bogies can then be pushed away and ramps fitted in place to permit end loading.

The new eight-vehicle train (excluding locomotive and brake vans) for the wholesale destruction of weeds along the permanent way, designed and equipped by the Chipman Chemical Company.

WEED-KILLING TRAIN FOR BRITISH RAILWAYS

55 TRACK MILES TREATED IN ONE RUN

A mobile weed-killing unit, characterised by the simplicity of its layout and the arrangements made for ease of maintenance, is being brought into operation on British Railways. The unit, a train of eight vehicles, excluding the locomotive and the brake-van, is shown in the upper illustration. The eight vehicles consist of six 14-ton tank wagons having a combined capacity of 15,000 gallons, for carrying the weed-killing solution, and two converted passenger-luggage vans—one carrying the main pumping and spraying equipment and a workshop, and the other arranged as living accommodation for the train crew.

The tank wagons are linked in series by a flexible 4-in. main to the pumping and spraying equipment installed in the rear wagon and the weed-killer solution is distributed over an approximate width of 15 ft. by a system of nozzles; the side banks of nozzles are mounted on retractable booms controlled by hand levers inside the vehicle. The two lower illustrations depict the inside of the pump wagon and the extended distributor system below the rear wagon.

The train, like the earlier nine trains, is a joint venture promoted by British Railways and the Chipman Chemical Company, Limited, Plantation House, Fenchurch-street, London, E.C.3, who are the suppliers of the chemical weed-killer and who have designed and equipped the train. The normal crew of the train is four in number and includes the operator-in-charge, his mate and one fitter ; these three are railway employees and are permanently appointed to the train for a year's programme. The fourth man is also a railway employee provided by the district in which the train is operating at any given time; he is a local permanent-way inspector conversant with the track being traversed. A representative of the chemical company accompanies the train from time to time in an advisory capacity.

Since the period of the 1914-18 war, with the increase in traffic and the loss of skilled permanent-way men, it has become increasingly impracticable to keep the weeds down by hand methods. The cost of hand removal has not been accurately determined as this operation is carried out simultaneously with other maintenance work, but the cost of chemical spraying is known to be considerably less than that of hand methods and is also more complete—the whole plant being killed, whereas with hand hoeing some of the perennial growth is left in the track ballast and will begin to take root almost immediately.

The early application of chemical weed-killer by small equipments mounted on platelayer's trolleys led to the design of the spray trains capable of carrying out this work on a broader basis. In the early 1930's, the annual consumption of liquid weed-killers on the railways in the United Kingsom was about 250 tons. By 1954 the consumption had increased to a figure of about 11,000 tons. During 1953, approximately 17,400 miles of track were treated from spray trains while over 23,000 miles were sprayed from smaller equipments mounted on hand-propelled trolleys. On these figures it has been found that the cost of track spraying using the larger train units is approximately £15 per mile, this including the cost of materials, labour, locomotive hire and operating costs.

MACHINERY AND EQUIPMENT

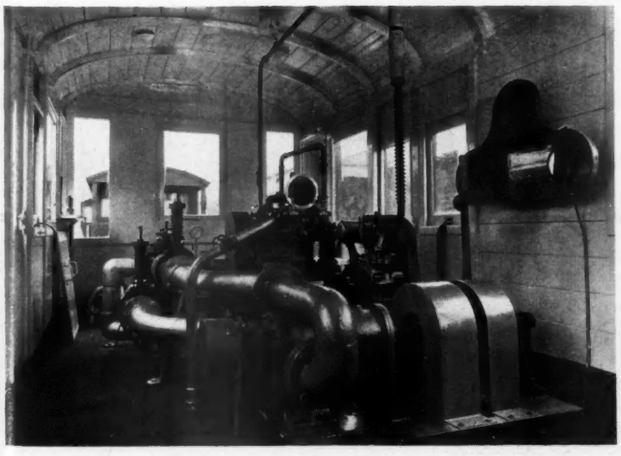
As already stated, the new train normally comprises eight vehicles—the six tankers and the two converted vans, one of which carries the machinery and equipment, the other to be used by the crew as living quarters.

The machinery and equipment vehicle is divided into two compartments. The larger, 18 ft. by 7 ft. 8½ in., contains the main pumping and spraying equipment and is shown in the illustration below; the smaller, 12 ft. long, provides space for a workshop and storage for tools and loose equipment.

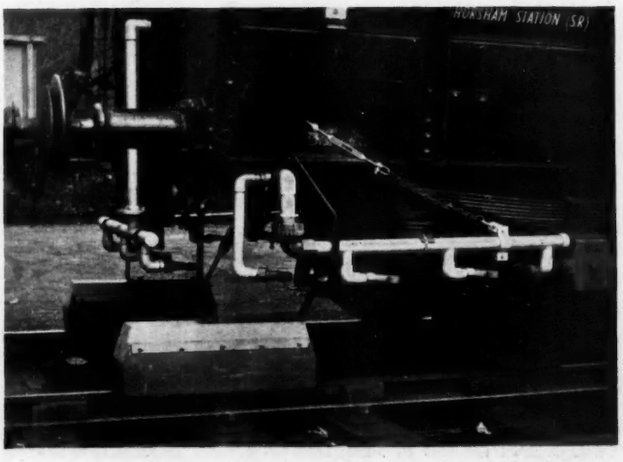
The principal piece of equipment is the 4-in. rotary drum pump driven through a rim-type friction clutch by Brammer belting running off pulleys on the vehicle axle. It has a capacity of 8,400 gallons per hour when running at 410 r.p.m. and operating against a head of 30 lb. per square inch. Other fixed equipment in the van includes a compressor and air receiver of approximately 20 cub. ft. displacement, the compressor having twin cylinders of 3½ in. stroke by 3⅛ in. bore, and being air cooled. This supplies the compressed air used to agitate the diluted weed-killer when priming the tanks as described later. The 5½-h.p. Villiers petrol engine used for driving the compressor is also used to drive a 1-in. Megator pump. This pump draws weed-killer solution from the main 4-in. feed for stationary spraying in sidings and yards; using spraying lances connected to the small pump by ½-in. hose, it is possible to treat an area within a radius of 120 ft.

Sundry equipment carried in this compartment includes a speedometer with 6-in. dial, calibrated from 0 to 50 m.p.h., to be seen on the right-hand wall of the van in the illustration below; portable gas-storage cylinders for heating and lighting; and a 2-in. portable Warsop pump, driven by a petrol engine, used for transferring liquid concentrate from the company's supply wagons to the tank wagons of the train, and suitable lengths of 2-in. hosing for this purpose.

The six 14-ton tankers are each fitted with a three-way bottom outlet cock which enables any one tanker to be drawn from as required. Each vehicle is connected to the air receiver in the



Interior of the equipment vehicle showing the main 4-in. pump in the foreground with the air compressor and its motor behind.



The weed-killing solution is sprayed on to the track from three banks of nozzles; the outside banks are shown here in the housed position.

machinery vehicle and a valve allows each tanker to be "blown" independently; the internal piping for this operation is supported about 4 in. from the bottom of the tank, runs the full length of the barrel, and is perforated at a number of points so that the air is discharged uniformly through the contents of the tanker. Vertical baffles, drilled at the top and bottom, have been welded into the tankers to break down the mass of surging liquid when the train is running. Dipsticks graduated in units of 50 gallons have been provided. Three only of the tankers are fitted with vacuum brakes.

PRIMING THE TRAIN

In order to load the weed-killer solution, the train is assembled alongside tank wagons bringing a liquid concentrate of the weed-killer from the manufacturer's works. A 2-in. portable pump, housed in the machinery van, is unshipped and used to transfer the concentrate to the train—usually 625 gallons to each tanker. Water is then added to dilute the solution for use at a strength of three parts of water to one of concentrate.

The compressor in the machinery van is then set to work until the air receiver contains air at 75 lb. per square inch, when the compressed air is discharged through the contents of a filled tanker. This operation, carried out three times, is generally sufficient to agitate the contents and to form a uniform mix, checked by taking specific-gravity readings at three depths in the fluid. While the water is being added and the mixing is being carried out the next tanker is filled with the concentrate and so on for the rest of the train. Under favourable conditions —handy siting of a water tower and availability of a locomotive for shunting the train—the whole operation of unshipping the hoses and pump, transferring the concentrate, filling with water and mixing, and re-loading the equipment, can be completed in 1½ hours. Experience has shown that, under operating conditions and with the small difference in specific gravity, very little separation of the concentrate occurs.

TRAIN OPERATION

The weed-killer solution contained in the six tankers is drawn into the machinery van by the 4-in. pump; until the tankers are nearly empty the solution flows forward towards the pump under its own head, the pump acting primarily as a control on the rate of deposition. From the pump, the solution is distributed under pressure to the three spraying booms; each boom has a separate control valve. The centre boom is fixed and has three nozzles which cover the "4-ft." The two outside booms each have four nozzles and are used to spray the cess and the "6-ft." The outside booms are mounted on flexible pipe joints and can be swung alongside the wagon to avoid track furniture; swinging the boom into the close position automatically cuts off the supply of the weed-killer from that boom. The rail covers shown in the illustration have been provided to prevent the solution being deposited on the rail-head and thereby to anticipate complaints that the solution caused wheel slip, or other troubles, to following trains.

The normal rate of application of the solution is 280 gallons per mile spread over a total width of 15 to 16 ft. By being driven off the vehicle axle, the main pump ensures that over a speed range of 10 to 25 m.p.h. the rate of application is nearly constant.

The total capacity of the train is 15,000 gallons and it is therefore possible for a full-width spray to be applied over approximately 55 miles on one fill. It is possible—at a normal spraying rate of 20 m.p.h.—to spray approximately 100 miles in a working day if suitable arrangements can be made for filling the train. The programme so far arranged for this particular train covers about 2,000 miles on the Eastern Region and 660 miles on the North Eastern Region. Commencing on April 17, the programme continues through until the end of June, suitable break days being allowed for resting the crew and for carrying out maintenance work on the train and its equipment.

360-MW POWER STATION AT SKELTON GRANGE

GOOD RESULTS FROM POOR QUALITY COAL

The Skelton Grange power station, which forms part of the generating capacity of the Yorkshire Division of the Central Electricity Authority, was first placed in operation nearly four years ago; and its completion is expected early next year when the installed capacity will be 360 MW. It is situated three miles from the centre of Leeds in a mining area and utilises local coal which would be incombustible in other than pulverised form. In spite of the fact that the calorific value of this fuel does not exceed an average of 9,700 B.Th.U. per pound, the thermal efficiency of the station during the year ended December 31, 1954, based on the electricity sent out, was 28·94 per cent., the output being 1,428 million kilowatt-hours and the average monthly load factor 87·6 per cent.

Another point of interest is that the 360 million gallons of cooling water per day, which will eventually be required, will be obtained partly from the River Aire, partly from the Aire and Calder canal and partly from Leeds sewage effluent. As the flow of the river varies considerably, cooling towers have also been installed and an interesting system of re-circulation is being used.

CIVIL ENGINEERING

The civil engineering work necessitated by the construction of the station included the excavation of 750,000 cubic yards of material, part of which was rock. Some 36,000 tons of coal were also recovered and consumed at the Kirkstall power station. The spoil was employed to form embankments for the ash pond and the railway sidings as well as for levelling. An adjacent low-lying swamp is also being covered with ash slurry to above flood level and will later be employed for development.

The turbine house, which is 750 ft. long and 74 ft. wide, is divided into 24 bays. The main structural members consist of reinforced concrete portal frames, which support a thin shell concrete roof as will be seen in Fig. 1. The beams which carry a 150-ton travelling crane form an integral part of this frame. The roof was constructed by using a travelling shutter running on the crane rails. The appearance has been improved by making the radius of curvature of the bottom of the main ribs the same as that of the shell roof. Details of the design of this part of the station have already appeared in ENGINEERING.*

The boiler house, which is of steel frame construction, is 650 ft. long by 200 ft. wide by 150 ft. high. The control room, laboratory and offices are connected to the turbine house by a covered walkway.

The main building contractors were H. Arnold & Sons, Limited, Doncaster; Holloway Bros. (London), Limited; Holst and Company, Limited, Berkamsted, Hertfordshire, and Marples, Ridgway and Partners, Limited, London, S.W.1. The boiler house steel work was supplied by Dorman Long and Company, Limited, Middlesbrough.

COAL HANDLING

The greater part of the coal required is delivered by rail to an internal system comprising about 8 miles of track and sidings. This system crosses both the River Aire and the Aire and Calder Canal by pre-stressed concrete bridges of bow-string design, which were constructed by Holst and Company, Limited, and are said to be the first railway bridges to be built in this country on which pre-stressing was employed. Facilities have also been provided for delivering coal by road from near-by open-cast sites.

The coal is discharged from the railway wagons by three rotary tipplers and is taken by enclosed conveyors, with a capacity of 800 tons per hour, either to the boiler bunkers or to the storage ground. The latter has a capacity of 120,000 tons and is fed by a radial conveyor. Trimming is effected by bulldozers and carry-alls. This portion of the equipment was constructed by International Combustion Limited, Woburn Place, London, W.C.1.

STEAM RAISING PLANT

The steam raising plant, which was also constructed by International Combustion Limited, at present consists of one 550,000 lb. and six 360,000 lb. water-tube boilers, which supply steam at a pressure of 975 lb. per square inch and a stop valve temperature of 940 deg. F., the feed water temperature being 380 deg. F. Pulverised fuel for each of the smaller boilers is supplied from three mills with individual outputs of 10 tons per hour. These boilers, which have a total heating surface of 11,610 sq. ft. and a combustion chamber volume of 29,000 cub. ft., are interesting as being the first in this country to have the steam temperature controlled by tilting the corner burners. The resulting raising or lowering of the flame mass which this causes reduces or increases the furnace cooling surface presented to the gases, thus providing the

* ENGINEERING, vol. 168, page 609 (1949).

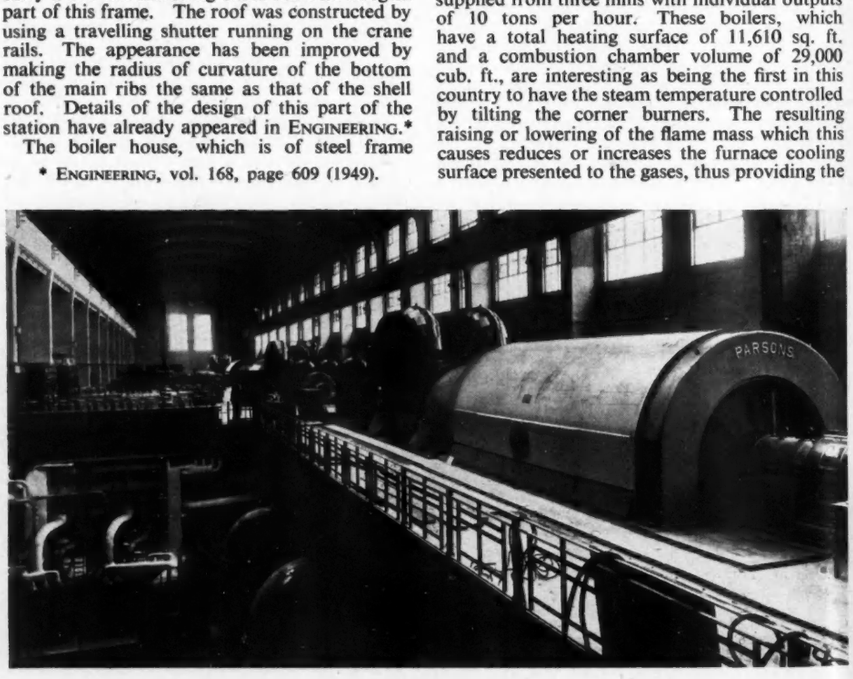


Fig. 1 Turbine room at Skelton Grange power station showing roof construction and one of the 60-MW turbo-alternators.

required exit temperature. This operation is performed by pneumatic cylinders, which are controlled by Kent Multelec steam temperature recorders.

The Melesco superheaters, which have a heating surface of 17,350 sq. ft., are of the horizontal draining pattern and are arranged in three banks in series. Passes are provided to maintain the gas flow through the superheaters within the operating limit of the burner control. A two-tier Senior economiser with a heating surface of 22,848 sq. ft. is placed between the superheater and an Usco plate air heater, the heating surface of the latter being 91,507 sq. ft. Draught is provided by two induced draught and two forced draught fans of Howden construction on each boiler, and the grit is arrested by Sturtevant electrostatic precipitators.

The steam conditions on the two boilers which are now under construction are the same as those mentioned above, but the output of each will be 550,000 lb. per hour, the total heating surface being 12,450 sq. ft. and the combustion chamber volume 45,100 cub. ft. They each will be fired by four mills with outputs of 11 tons per hour, the exhausters being of the International Combustion Company's two-stage design. The furnaces are of the shaft type and the high-temperature bank of the superheater is suspended in the furnace outlet, there being no water-cooled screen in front of it. The low-temperature section of the superheater comprises two self-draining banks. A two-bank Senior economiser with a heating surface of 42,240 sq. ft. is installed between the superheater and two Howden regenerative air heaters, the heating surface of which is 129,500 sq. ft. The temperature of the steam from these boilers is also adjusted by tilting the burners, the by-pass round the low-temperature section of the superheater being controlled by a damper.

All the boilers are, or will be, equipped with Bailey automatic control.

After passing through the electrostatic precipitators the flue gases are discharged into two 375-ft. high reinforced-concrete chimneys which were built by Tileman and Company, Limited, 203 Knightsbridge, London, S.W.7, and by J. L. Kier and Company, Limited, 7 Lygon-place London, S.W.1.

ASH HANDLING

The ash- and dust-handling plant, which was constructed by Babcock and Wilcox, Limited, Farringdon Street, London, E.C.4, is in two sections, one serving the six smaller and the other the three larger boilers. In each section the ash from the furnace bottoms is periodically washed away by Hydro-jet high pressure sluiceways to crushers which, in turn, discharge into the ash sump. The dust and fly-ash from the boiler passes, collector hoppers and electrostatic precipitators are extracted by feeder ejectors, by Windswept dust valves and Hydrovactor ejectors. The dust-water mixture is discharged into a gravity sluice whence it is led to the ash sump. The capacity of the system is 150 tons per hour.

From this sump the dust and ash is pumped by Hydroseal two-stage pumps a distance of some 5,000 ft. to ponds. The casings and impellers of these pumps are of hard alloy to resist abrasion and are designed so that grit is kept out of the glands and other places where the clearances are fine. Duplicate pumps are provided for each unit and there are also other pumps for supplying the water for high pressure sluicing and sealing.

GENERATING PLANT

The generating plant will ultimately consist of six 60-MW machines constructed by C. A. Parsons and Company, Limited, Newcastle-on-Tyne, and designed to generate three-phase current at 11 kV and 50 cycles when running at 3,000 r.p.m. and exhausting at a vacuum of 28·5 in. The turbines, of which five are at present in operation, are of the three-cylinder type, the high-pressure cylinder, which contains 23 sets of blades, being constructed in the form of a rigid symmetrical tube and the horizontal joint being held tight by clamps. There are 19 sets of blades in the intermediate and six double-flow sets in the low-pressure cylinder. The material used for the blading and the impulse nozzles is stainless iron, which contains 12 to 14 per cent. of chromium.

The high-pressure rotor is of molybdenum steel, the body consisting of a hollow forging which is integral with the shaft at the high-pressure end and closed at the exhaust end by a second forging, which is extended to constitute the shaft in that position. The walls of the hollow forging are comparable in thickness with the metal of the surrounding cylinder, so that changes in clearance due to differential expansion are a minimum.

The intermediate-pressure rotor is of solid construction and is machined from a single steel forging, while the low-pressure cylinder consists of a central shaft on which a number of forged steel discs are shrunk. The rims of these discs are grooved to carry the blading, a method of construction which reduces the size of the forging and enables alloy steel to be used for parts which are subject to high stress.

The shafts are located axially by thrust blocks of the pivoted-pad type, that in the high-pressure cylinder being movable between fixed limits. There are two steam chests, each of which contains a single-sealed valve. The governor valves, which are operated by oil relays, are of the double-beat balanced pattern. The centrifugal governor, power-oil pump and lubrication pump are driven through gearing from the main shaft. The power pump supplies oil for the governor pilot system and relays as well as feeding the shaft seals on the hydrogen-cooled alternator. The turbine room is shown in Fig. 1.

The turbines exhaust into condensers with a cooling surface of 60,000 sq. ft., from which the condensate is withdrawn through five stages of feed heating to the boilers. Twelve feed pumps will eventually be connected between the low and high-pressure feed heaters. Of these pumps nine with a capacity of 720,000 lb. per hour will be electrically driven, and will be of Mather and Platt manufacture. The other three will be steam-driven sets, will each have a capacity of 660,000 lb. per hour and will be provided by G. and J. Weir, Limited, Cathcart, Glasgow, S.4. Make-up is obtained through two evaporators, the manufacturers of which are Aiton and Company, Limited, Derby, and by two others which have been supplied by G. and J. Weir, Limited.

COOLING WATER SYSTEM

As already mentioned, the cooling water required for the operation of the station is drawn partly from the River Aire and partly from the Aire and Calder canal, while Leeds sewage effluent is also utilised. As the river flow and the temperature of the water vary considerably, two natural-draught cooling towers, constructed by Film Cooling Towers, Limited, Kew Bridge, Brentford, Middlesex, are already provided and a third is under construction. The towers are built of reinforced concrete and are of the hyperbolic type, each being capable of cooling 2,600,000 gallons per hour from 85 deg. to 70 deg. F. The diameter of each tower at the top of the pond wall is 192 ft. and the height 286 ft. above this level, while the mean area of the internal cooling portion of the stack is 26,000 sq. ft.

An unusual feature of the lay-out is that the towers are located on ground behind the power station at a level 30 ft. higher than the turbine house basement. The ponds at the tower base have therefore sufficient head for the water to flow through the condensers by gravity. The head of water in the cooling tower ponds is in parallel with the riverside pumps; and the common cooling water discharge for the condensers is to a seal pit, so that full syphonic recovery from the latter is ensured. The cooling tower pumps draw from the seal pit and discharge to the cooling tower distribution system. This arrangement has the advantage of providing sufficient storage of water for a short period and of preventing the turbines from going over to atmosphere should the circulating water pumps trip. A storage trough with a capacity of 12,000 gallons is arranged inside and near the top of the tower for supplying the general and fire water services.

Water is extracted from the river through Brackett screens and a mixing chamber by four pumps which were manufactured by W. H. Allen and Sons, Limited, Bedford. They are driven by 800-h.p. 3,000-volt British Thomson-Houston Company motors, the capacity of each unit being 2,600,000 gallons per hour. Having passed through the condensers the water flows back into the river. Transfer pumps also deliver water from the river to the canal at a point 1½ miles downstream from the station, while water is drawn from the canal into the river over a spillway for further use in the station. This spillway, which was constructed by Messrs. Marples, Ridgway and Partners, and is illustrated in Fig. 2, consists of concrete walls of trapezoidal shape and is arranged so that the levels of both river and canal are maintained, and the river is not therefore irregularly depleted. It is also designed so that the level of the canal is never lowered by more than 2½ in. Water is further circulated to the Leeds Corporation Sewage Works where bacteria beds covering 26 acres are used as a cooling medium. The Leeds sewage effluent and the recirculating water is returned to the power station cooling system at the rate of 1,250,000 gallons per hour.

The cooling water system is controlled from a panel which was supplied by Standard Telephones and Cables, Limited, New Southgate, London, N.11. The principal feature of this is a miniature diagram similar to those commonly used for switchgear. This diagram, which is illustrated in Fig. 3, carries symbols showing the various penstocks, spillway and valves; these are illuminated when the associated valves are opened. Similarly, the symbols indicating the pumps are illuminated when these are running. All the control switches, push buttons, ammeters

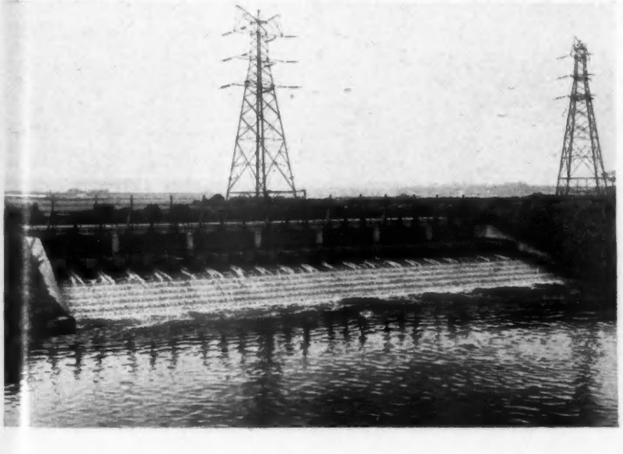


Fig. 2 Spillway over which water is drawn from the Aire and Calder canal into the River Aire so that the water levels are maintained.

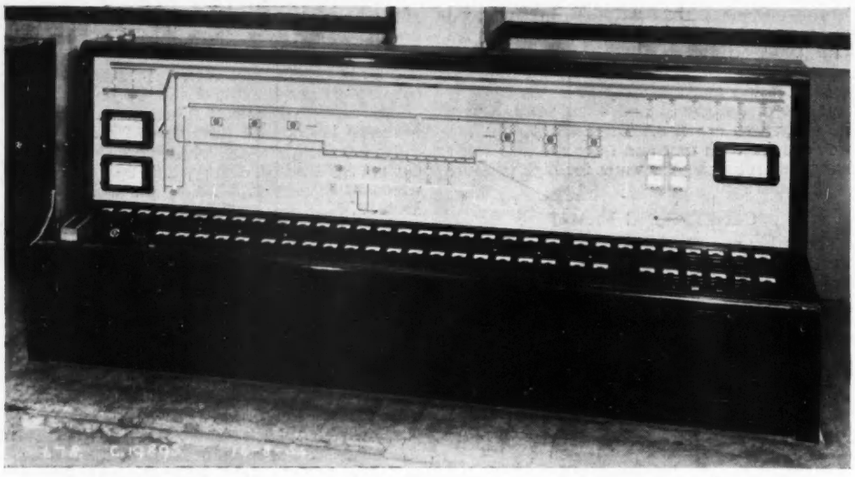


Fig. 3 Miniature diagram and switchboard from which the cooling water system is controlled.

and position indicators are mounted below the symbols to which they relate. The "chlorine" condition of each condenser chlorinating plant and the condition of the screens are also indicated by lamps, while still other lamps show whether the condenser valves are on "local control."

ELECTRICAL EQUIPMENT

The Parsons alternators, which, as has already been stated, are hydrogen-cooled, have a rated output of 60 MW at 0·8 power factor and generate three-phase current at 11 kV. They are solidly connected to 70 MVA, 11/134 kV transformers, which were constructed by the Hackbridge and Hewittic Electric Company, Limited, Walton-on-Thames. These transformers are fitted with on-load tap changers of the reactor type, which give a voltage range of ± 10 per cent. in 14 steps. The 134-kV connections are taken out through single core sealing ends, which are mounted on the transformer covers in separate chambers to facilitate testing.

Single-core Pirelli-General cables are used for connecting the transformers to the adjacent outdoor switching station, where there is accommodation for 24 circuits, 20 of which are already in commission or are being erected. This switching station, which is illustrated in Fig. 4, is of the low double bus-bar type. It is equipped with bulk-oil-dead-tank Shuntarc 600-ampere circuit-breakers with a rupturing capacity of 2,500 MVA, which were manufactured by the British Thomson-Houston Company, Limited, Rugby. Each phase of these circuit-breakers is accommodated in a separate floor-mounted tank and there are two breaks per phase. The arc-control chambers are self-compensated and a non-inductive resistance is automatically placed in series between the fixed and moving contacts immediately after the interruption of the short-circuit current. The re-striking voltage transient is thus controlled so as to secure equal distribution of the fault current over the two breaks and to reduce to a low value the overvoltage which occurs when breaking small inductive or capacity currents. The performance of the arc-control devices is also greatly improved at low arc-currents. The circuit-breaker is closed through a quick-acting tripping train of the toggle type by a solenoid which is supplied with direct current, thus reducing the time between energisation and contact separation to a minimum. The total break time at any duty within the specified breaking capacity is 3 cycles.

The interiors of the oil-filled terminal bushings are divided into vertical annular ducts by concentric insulating baffle tubes. These prevent the formation of chains of impurities between the conductor and the outer porcelain without restricting the oil circulation. The current transformers are accommodated in the top plate so that the bushings can be withdrawn as a complete unit. The voltage transformers are of the electromagnetic wound type and are suitable for direct connection to the 132-kV line. The bus-bar selector and feeder-isolating switches are of the double-break rotating-post gang-operated type.

The substation is equipped with oil handling plant manufactured by Metafiltration Company, Limited, Hounslow. This is connected by permanent piping to each circuit-breaker so that filling and emptying are facilitated.

CONTROL ROOM

The switchgear is controlled from a room in the administration building of the station, the equipment being of the sheet steel cubicle, semi-miniature corridor pattern. In addition to the normal complement of instruments and synchronising equipment, telephone-type alarm annunciators and discrepancy-type semaphore indicators are provided to show the isolator positions.

The substation is at present connected by 132-kV overhead lines to Leeds, Wakefield, Kirkstall and Ferrybridge. Two 275-kV lines, which will connect it to Monk Fryston, near Ferrybridge, are, however, being erected and will be supplied through 132/275-kV transformers.

PROTECTION

Magnetic-balance generator protection is provided to give overall protection to the alternator step-up transformer and the associated unit transformer. Current-summation bus-bar protection is also installed to deal with earth faults and gives an alarm if a fault occurs in the small wiring or current transformer secondaries.

Faults or other abnormal conditions on the electrical equipment throughout the station are indicated by an alarm system supplied by Standard Telephones and Cables, Limited, which enables some 300 indications to be given in the control room. These alarms are grouped so that they can be readily identified with the associated equipment and, when operated, cause a horn to sound and the appropriate window to be illuminated intermittently. The relays which form part of this system are supplied with direct current at 50 volts. The lamps, however, are normally fed with alternating current, although they can be switched to direct current should the mains supply fail.

AUXILIARY SUPPLIES

The essential supplies for auxiliaries are obtained from 6 MVA, 11/3-kV transformers which are directly connected to the alternators. Interconnectors are provided from each unit switchboard to a two-section main 150-MVA station switchboard, each section being connected through the 132-kV switchgear to a 10-MVA, 132/3-kV station transformer. The switchgear and auxiliary motors associated with the first six boilers are connected via 1·5-MVA double-wound 3-kV/415-volt transformers to the unit switchboards. The induced and forced-draught fans on the other three boilers are supplied at 3 kV from further switchboards, which in turn supply other boiler auxiliaries through 1·2-MVA, 3-kV/415-volts double-wound transformers. The circulating water pumps, cooling tower pumps and ash pumps are all supplied at 3 kV. A double-circuit overhead line, which is carried on H-poles, provides a supply to each pump, and the same poles support a 20-core catenary suspended control cable which is run to the transfer pump house about one mile down river from the station. Two 500-kVA, 3-kV/415-volt transformers, which are connected to the station switchboard, provide low-tension power for the coaling plant, whilst the two turbine-house and two boiler-house switchboards are each supplied from 750-kVA, 3-kV/415-volt transformers. Lighting and heating for the complete station are provided from four 400-kVA, 3-kV/415-volt transformers.

All the 3-kV and 415-volt switchgear was manufactured by English Electric Company, Limited, Kingsway, London, W.C.2, as were auxiliary transformers for the first half of the station. The auxiliary transformers for the second half are being supplied by the Yorkshire Electric Transformer Company, Limited, Dewsbury.

The original designs for the station were prepared under the direction of Mr. F. Nicholls, who was then the city electrical engineer of Leeds. Since vesting day the constructional work has been carried out under the superintendence of the Controller of the Yorkshire Division, British Electricity Authority (Mr. G. A. Vowles), and the supervision of Mr. F. Barrell, the Generation Engineer (Construction), who was previously the deputy electrical engineer-manager of Leeds.

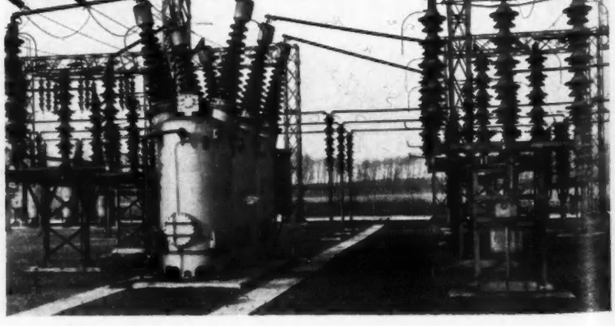


Fig. 4 Outdoor switching station at Skelton Grange showing 2,500-MVA 132-kV oil-circuit breaker flanked by rotating post isolators

THE PHYSICAL SOCIETY'S EXHIBITION

EVIDENCE OF TECHNOLOGICAL PROGRESS

Current technological and scientific progress will be well represented by exhibits at the 39th Physical Society Exhibition, which is to be held this year at the New Hall of the Royal Horticultural Society, Westminster, London, S.W.1. The exhibition will open on Monday, April 25 and close on Thursday, April 28, and it is anticipated that some 140 exhibitors will be taking part. Scientific instruments, measuring equipment and apparatus based on physical principles only recently explored are to be displayed, and exhibitors will include university departments, Government establishments and a large number of industrial firms. Among items of special interest will be colorimetric instruments, chromatographic and sonic gas analysers, automatic titration equipment, particle counters, miniature electronic components, infra-red spectrometers and analysers, apparatus for checking the accuracy of turbine blades, a synthetic-rubber high-voltage insulating material, computers, radiation monitors, and a new liquid-air machine. A descriptive illustrated handbook of the exhibition, together with other details, may be obtained from the Society's exhibition secretary at 1, Lowther-gardens, Prince Consort-road, London, S.W.7.

LIQUID-AIR MACHINE

Two items of engineering interest which Philips Electrical, Limited (Century House, Shaftesbury-avenue, London, W.C.2) propose to exhibit are an X-ray intensifying tube for industrial applications and a thermodynamic or liquid-air machine. The X-ray unit enables metals (aluminium and steel) to be examined by fluoroscopy in dim daylight, since it gives a brightness gain of more than 1,000, and permits the penetration (kilovoltage) of the X-ray tube to be about 40 to 50 kV lower than that used for ordinary fluoroscopy; a much improved contrast is thus obtained. The model to be demonstrated includes an X-ray generator of 140 kVP maximum tension and will deal with aluminium up to 3½ in. thick and steel up to ⅝ in. Penetrameter measurements are shown.

The second exhibit is the result of a series of developments carried out by the Philips Research Laboratories and is a gas refrigerating machine working on the Sterling cycle and believed to be of an entirely new pattern. It is illustrated in Fig. 1 and is known as the Philips Liquid Air Installation PW 7000. It is capable of liquefying air and the makers state that a temperature of −200 deg. C. can be obtained quickly and easily, a figure considerably lower than can normally be obtained with more orthodox compression refrigerators.

The principle of the machine is similar to that of a heat engine, in which energy in the form of heat is transformed into mechanical energy. If, however, no heat is supplied and the machine is driven by an external power unit, it can be made to function as a refrigerating plant. The machine operates therefore on a reversible cycle.

As can be seen it is comparatively small, and is simpler in construction than the "cascade" type of machine; it also compares favourably in efficiency and simplicity with conventional compression refrigerating machines. Because refrigeration takes place without compression, and since there are no expansion valves, the liquid air is pure and free from oil contamination, dust and dirt. The starting period is brief, and liquid air can be produced within 15 minutes of switching on, and subsequently at a rate of 5 litres per hour, when the ambient temperature is 20 deg. C. Moreover, the plant will run continuously for 16 hours in air of 50 per cent. relative humidity.

After the working period, de-frosting of the air-intake head becomes necessary, since moisture and carbon dioxide are deposited there in solid form; this operation, including the starting time for the next working cycle, takes up to one hour. Refrigerating capacity can be varied both by changing the speed of rotation and by altering the gas pressure within the working space of the machine.

The installation comprises the liquefier with built-in air drier, carbon-dioxide remover and de-froster, located on a common bed-plate with the 10-h.p. squirrel-cage motor; the drive operates through a flexible uni-directional clutch. The control panel contains indicating gauges, hour meter and control gear, and safety devices are incorporated to close down the plant in the event of failure in the cooling system, pressure system, or lubricating system.

The machine's applications include the local preparation of liquid air in the laboratories of universities, hospitals, research establishments and industrial concerns, and it is expected that models will shortly be built for use in cooling boxes. It may also be employed to effect the liquefaction of pure gases such as nitrogen, argon, oxygen and methane, and will assist therefore in the provision of liquid baths with well-defined boiling points.

VAPOUR-PHASE CHROMATOGRAPH

A recent version (designated EM3A) of their EM3 electron microscope; a mass spectrometer and recorder (MS3) suitable for isotope abundance ratio determinations and for the analysis of hydrocarbon and other gaseous mixtures; a range of vacuum equipment; and a vapour phase chromatograph are among the equipment to be displayed by Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17. In addition, certain prototype and experimental apparatus will be shown. These include a double-focussing mass spectrometer (MS7) for the general analysis of solids; an infra-red radiation pyrometer designed primarily for use in studying temperature distribution in the tool-tip region during metal cutting operations; a null indicator; and a chopped-voltage testing set.

The vapour-phase chromatograph, which is in production, is a means of analysing and separating gases and volatile liquids. It is shown in Fig. 2. The sample is injected on to the top of some inert packing contained in a glass column, and consisting of kieselguhr impregnated with

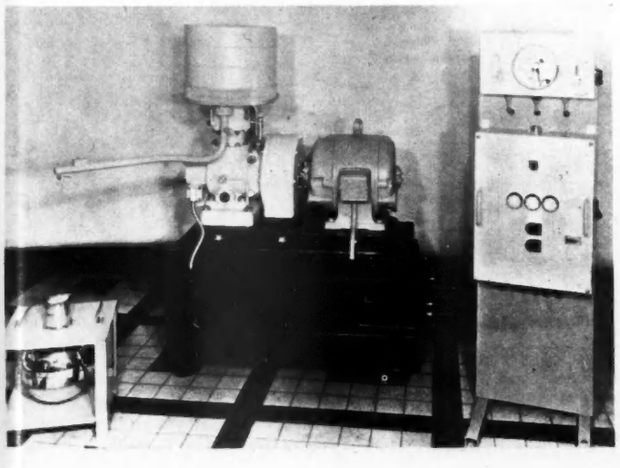


Fig. 1 The Philips Liquid Air Installation PW7000 is capable of producing a temperature of − 200 deg. C. and may be used for the liquefaction of various gases. It operates on a reversible Sterling cycle.

Fig. 2 The Metropolitan-Vickers vapour-phase chromatograph is a means of analysing and separating gases and volatile liquids. Its action depends on the time taken for a flow of nitrogen to carry a particular gas through a column of known length.

Fig. 3 In the Unicam flame photometer, sample materials are finely dispersed by a concentric-jet atomiser and fed to a burner, from which light passes through a silica-prism monochromator to a photo-multiplier. Results are read from a spot galvanometer.

Fig. 4 By means of a turbine blade-edge microscope made by Taylor, Taylor and Hobson Limited, an image of the normal cross-section of a gas-turbine blade can be compared with a standard at a magnification of × 40.

a high-boiling-point solvent, usually dinonyl phthalate.

A continuous flow of nitrogen passes through the column and carries the sample along as vapour. The components of the mixture travel at varying rates, and the time taken for each to negotiate the column is a characteristic of that component for a particular set of operating conditions; it depends on such factors as vapour pressure and solubility in the stationary liquid phase (high-boiling-point solvent). The component which is least soluble and of the highest vapour pressure emerges first. The relative concentration of each component in the nitrogen stream is indicated by a thermal conductivity cell in the outlet line, and is recorded as a series of peaks of conductivity in terms of time.

The glass column has a spiral path length of 6 ft. and can be heated to any temperature up to 150 deg. C. When desired a different liquid phase may be substituted in order to improve separation, and this can be quickly carried out by removing the column. Liquid samples—normally of 0·05 c.c.—may be introduced by hypodermic syringe, and gases are admitted by opening a valve and forcing in a predetermined quantity of sample. The chromatograph may be adapted for process monitoring work by the provision of an automatic valve and control.

The flow of nitrogen is controlled by means of needle valves and is indicated by a variable-flow meter. Inlet and outlet pressures are indicated by dial-type pressure gauges and a vacuum pump is used when it is necessary to operate with an outlet pressure of less than 760 mm. of mercury. Provision is also made for temperature measurement and control.

Good separations can be obtained with many different kinds of compound, for example, hydrocarbons, alcohols, aldehydes and ketones. In order to carry out quantitative analyses the instrument should be calibrated with the given components or, for greater accuracy, with a synthetic blend. The chromatograph is especially useful in qualitative analysis since, for a particular series of organic compounds, there is usually a simple relationship between the time of emergence and the chain length.

FLAME PHOTOMETER

On the stand of Unicam Instruments, Limited, Cambridge, will be shown a double-beam infra-red spectrometer and a flame photometer. The photometer, which is known as model SP900, appears in Fig. 3. In this instrument an air supply at 24 lb. per square inch pressure operates a concentric-jet atomiser to disperse the sample material in a finely divided form. This feeds a burner using either propane or acetylene, depending on the flame temperature required. Pressure gauges and controls are located in the atomiser compartment and a funnel feed to the atomiser is mounted on the front panel. The burner is located at the back of the instrument.

Light from the burner, which gives a flame of stable intensity, passes through a silica-prism monochromator of high light-gathering power to a photo-multiplier. The monochromator is based on the compensated spherical-mirror design described by Czerny and, in conjunction with the photo-multiplier and a lead-sulphide cell, is suitable for measurements ranging from 250 mμ to 2·7 μ. Wavelength selection is made by varying the angle of a Littrow mirror. Other controls include slit width, dark current and sensitivity adjustments.

The radiation leaving the exit slit is chopped at 100 cycles per second and focussed by a concave mirror to the selected detector; the use of chopped radiation ensures good zero stability. A homodyne rectifier, with phasing pulses taken from the chopper disc, converts the alternating current to a direct-current signal. The result is displayed as a direct reading of emission line intensity on a spot galvanometer having an open scale and a high speed of response If required, the galvanometer can be connected to a standard recorder.

TURBINE BLADE-EDGE MICROSCOPE

Among the exhibits to be displayed by Taylor, Taylor and Hobson, Limited, of Leicester, will be a " micro " alignment telescope with applications which include the manufacture of turbine shafts and bearings, air-frame jigs and machine tools; the " Talyrond " roundness-measuring instrument capable of recording departures from truly circular form to within 3 micro-inches; a turbine-blade form projector for measuring blade cross-section; and a turbine blade-edge microscope.

This latter instrument, which is illustrated in Fig. 4, provides a means of critically viewing in full daylight the leading and trailing edges of gas-turbine blades at a magnification of × 40. Any part of the edge can be viewed to within $\frac{1}{8}$ in. from the root or shroud and blades up to $2\frac{1}{2}$ in. in width and as long as desired can be accommodated. The field of view at the blade edge is 0·18 in. in diameter.

The microscope works on a light-slit principle. A narrow band of light is projected at an angle round the edge of the blade to delineate the section, and is viewed obliquely; the image seen through the eyepiece is that of the normal cross-section of the blade. The observed shape is compared with a master drawing prepared at 20 times full size on a card $3\frac{1}{4}$ in. by $4\frac{1}{4}$ in., the card being slipped into a holder on the instrument. The card is seen through an eyepiece of × 2 magnification, thus providing the total × 40 magnification required.

The two images are seen superimposed, and the brightness of the drawing image relative to the blade image can be adjusted so that both dark and bright blades may be examined. Blades up to 8 in. long are held against a V-fitting by means of a spring plunger. This instrument is in production.

TITRATION, PYROMETRY AND CORROSION TESTING

In discussing the instruments to be exhibited by the Cambridge Instrument Company, Limited, 13 Grosvenor-place, London, S.W.1, mention can be made of only a few.

Of special interest are a corrosion voltmeter, an infra-red pyrometer and an electrical titration apparatus. Other items include a modern form of Kelvin bridge with a measuring arm comprising ten steps of 0·001 ohm, designed for checking low resistances or for specific resistance tests; an electronic recorder for industrial use; a dissolved-oxygen recorder and a Wheatstone bridge for investigating the conductivity of solutions.

The " electro-titration " apparatus was origin-

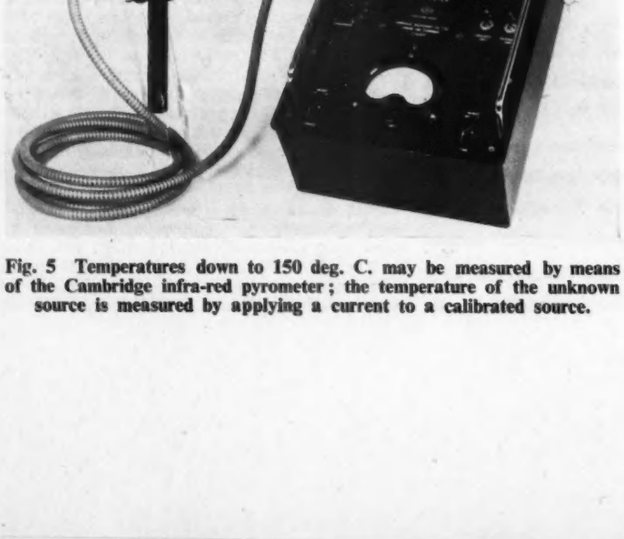


Fig. 5 Temperatures down to 150 deg. C. may be measured by means of the Cambridge infra-red pyrometer; the temperature of the unknown source is measured by applying a current to a calibrated source.

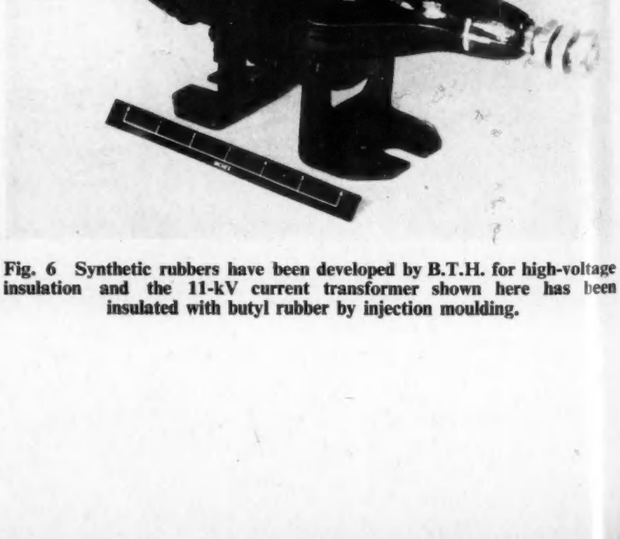


Fig. 6 Synthetic rubbers have been developed by B.T.H. for high-voltage insulation and the 11-kV current transformer shown here has been insulated with butyl rubber by injection moulding.

ally designed for the analysis of steels, but is suitable for use in volumetric analysis generally. It simplifies the problem of determining "end points" in coloured solutions and in its redesigned form incorporates a magnetic stirrer; this allows the motor to be placed beneath the platform where it is better protected and does not obstruct the use of electrodes and burettes. The motor rotates a magnet situated below the beaker and the rotating field so caused induces a similar motion of a suitably coated magnet in the solution, thus providing efficient stirring. The stirring magnets may be coated alternatively in polythene or glass depending on the circumstances. An improved arrangement of electrodes enables ordinary straight burettes to be used, and these, together with the electrodes, can be raised by operating a lever.

Fig. 5 shows the Cambridge infra-red pyrometer, which is capable of measuring temperatures down to 150 deg. C. The intensity of radiation from a calibrated source incorporated in the instrument is compared by reference to an indicator unit with the unknown radiation input. A 6-volt battery provides current for the known source and at the point of correspondence this current is proportional to the temperature of the unknown source. The current deflects a galvanometer calibrated in degrees and contained in the indicator unit.

The Cambridge corrosion voltmeter is a portable and simple outfit designed for field use. It measures the small electric potential between a structure and the soil, and this quantity enables an accurate estimate to be made of the location and extent of any corrosive action. In order to avoid errors due to the voltmeter taking current from the circuit, an indirect method of measurement is used: an equal and opposite e.m.f. is applied to the circuit to give a zero scale reading and the required voltage may then be observed by turning a switch.

SYNTHETIC-RUBBER INSULATION

Research on such materials as glasses, semiconductors and synthetic rubbers has recently been carried out in the laboratories of the British Thomson-Houston Company, Limited, Rugby, and some of the results of this work are to appear on the company's stand at the Physical Society Exhibition. In addition, B.T.H. will display a low-pressure mercury-vapour lamp which emits radiation capable of converting oxygen into ozone; a long-wave ultra-violet source; xenon flash tubes; "model motors" for evaluating electrical insulation; and high-efficiency electro-luminescent panels.

The development of materials and techniques for high-voltage insulation using synthetic rubbers will be represented at the exhibition by samples of these substances and examples of their use for various components. Butyl rubber is among the principal materials of this kind and Fig. 6 illustrates its application by injection moulding to a B.T.H. 11-kV current transformer; busbars insulated in a similar manner will also be shown.

Special grades of butyl rubber have been developed for this purpose, and new mould designs and injection-moulding techniques have been evolved for applying these compounds to coils, bars and other items. X-ray photographs will be displayed to show the disposition of copper coils within the mouldings and to illustrate the uniformity of the insulation.

(To be continued)

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COAL RESEARCH STATION

Open Days

The British Coal Utilization Research Association at Leatherhead will this year hold open days on Wednesday, Thursday and Friday June 8, 9 and 10. So that the work may be open to as wide an audience as possible, the centre will be open to visitors from professional organisations, public authorities, research associations, schools, and other bodies interested in the efficient use of coal. Wednesday will be reserved for members and their friends.

Labour Notes

RAILWAY STRIKE THREAT

An announcement that footplate men belonging to the Associated Society of Locomotive Engineers and Firemen would be called out on strike as from midnight on Sunday, May 1, followed very quickly on the publication last Friday of the findings of the Railway Staff National Tribunal that the union's latest demands on the British Transport Commission should be rejected in full.

Accordingly, for the third time in 18 months, the nation is faced with the possibility of an extensive railway stoppage. The fact that the threat comes at a time when considerable increases in railway wages have recently been granted, and when the Commission is scarcely in a position to make further substantial concessions, serves only to underline the seriousness of the existing situation.

The problem now confronting the Commission and the railway unions, for a decision to strike must be the concern of all the unions, seems to be how to appease the footplate men without raising further difficulties with the other railway employees. It is a problem in which the assistance and co-operation of the Ministry of Labour will undoubtedly be sought.

Unfortunately, time is short. Little more than a week remains in which to find a solution.

PROTRACTED NEGOTIATIONS

The present dispute had its origin last autumn, when, after lengthy negotiations on wage rates with the Associated Society of Locomotive Engineers and Firemen, the National Union of Railwaymen, and the Transport Salaried Staffs' Association, the Commission made an offer which it regarded as the utmost that could be conceded.

This "final offer" was accepted by the N.U.R. and the T.S.S.A., but rejected by the A.S.L.E.F., which decided to present its case to the Railway Staff National Tribunal for arbitration.

The N.U.R. joined in the appeal to the Tribunal only on behalf of its footplate members, but, later, was forced, by vehement agitation among its branches, to repudiate its agreement with the Commission respecting the other grades. The Tribunal eventually awarded the footplate men increases well in advance of those proposed by the Commission, and the N.U.R., dissatisfied with its further negotiations with that body, threatened to call out its members.

Strike action was averted by the setting up of a court of inquiry, the recommendations of which resulted in a reduction of the wage differentials created by the Tribunals' award to the footplate men. The N.U.R. accepted the court's proposals, but the A.S.L.E.F. wanted larger differentials and again appealed to the Tribunal, this time for an all-round increase of 8*s.* a week.

DWINDLING DIFFERENTIALS

If granted in full, this demand would have resulted in advances of from 1*s.* 6*d.* to 5*s.* 6*d.* a week on the offer made by the Commission in mid-January, after the report of the court of inquiry.

The N.U.R. was agreeable to accepting the Commission's proposals, which would have provided maximum basic rates ranging from £7 15*s.* a week for engine cleaners and shed enginemen to £9 15*s.* a week for drivers and motormen.

The A.S.L.E.F. did not approve of the Commission's offer and asked for £10 0*s.* 6*d.* a week for third-year drivers and motormen, and for higher maximum rates for the less highly-paid grades.

In its announcement, issued last Saturday, the A.S.L.E.F. states that the Tribunal's rejection of its demand is regarded as totally unsatisfactory, as it failed to recognise the union's case and, if put into operation, would seriously distort the wage-differential position laid down for locomotive men by the Tribunal itself as recently as November last.

That position, the union affirms, had been accepted by it in a moderate and reasonable spirit, as being "at least an attempt to check the continued and very serious dwindling of wage differentials, which has taken place over recent years."

Criticism of the A.S.L.E.F. has been forthcoming from certain sections of the N.U.R. The Manchester District Council of that union met at Manchester last Sunday and passed a resolution asking that the union's national executive committee should circulate its branches saying that the union did not support the policy of the A.S.L.E.F., as its action had already deprived members of the benefits of the Commission's offer made on January 13, with effect from January 10.

CIVIL ENGINEERING WAGES

Increases in the basic wage rates for navvies and craftsmen employed in the civil-engineering construction industry were announced by the Civil Engineering Construction Conciliation Board for Great Britain on April 15.

The new rates, granted in response to claims presented by the trade unions concerned, provide for an extra 1½*d.* an hour for navvies and labourers, and an extra 2½*d.* an hour for craftsmen.

The increases were due to come into operation on Monday last, April 18.

TRADE-UNION OFFICIALS' PAY

Salaries paid to full-time trade-union officials were discussed at the Easter conference of the Association of Engineering and Shipbuilding Draughtsmen at Whitley Bay, Northumberland.

A spokesman for the Association's officials stated that their salaries were now only about 63 to 78 per cent. above the level obtaining in 1939, whereas the wages of draughtsmen had risen during the same period by from 129 to 139 per cent.

Subsequently, the Association's executive committee recommended that the salaries of its leading officials should be increased to sums ranging from 109 per cent. to 116 per cent. above the amounts paid in 1939. These recommendations were carried.

At an earlier session, there were vigorous protests against the regular working of overtime. One speaker described systematic overtime as pernicious and intolerable. A resolution requesting that a campaign be instituted against overtime, which was referred to as tending to obscure the need for a proper basic wage, was carried.

REDUNDANCY IN AIRCRAFT INDUSTRY

Some 300 employees of Short Brothers and Harland, Limited, Belfast, engaged on the construction of military aircraft, have been given a week's notice, due to expire to-day, owing to lack of work.

It was announced on April 13 that, as a result of the Government's decision to restrict the production of Swift mark 4 aeroplanes, Vickers-Armstrongs Limited had found it necessary to cancel sub-contracts placed with Short Brothers and that, eventually, between eight and nine hundred employees at their Belfast works would become redundant.

The Ministry of Supply explained later that the Government had been much concerned to alleviate the effects of the cancellation of work on the Swift aircraft. Contracts for the production of eight Britannia aircraft had been allotted to Short Brothers and would provide employment for about 1,500 men by the middle of next year.

To provide work during the interval, the Ministry had made arrangements with the English Electric Company, Limited, for Short Brothers to be given a sub-contract for the construction of additional Canberra aircraft.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

BOURNEMOUTH
"Some Interesting Fan Applications," by R. C. Dick. Bournemouth Branch. Grand Hotel, Bournemouth. Mon., April 25, 8.15 p.m.

British Institution of Radio Engineers

LONDON
"Suppressed Aerials for the Aircraft High-Frequency Band," by K. J. Coppin. London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., April 27, 6.30 p.m.
CARDIFF
"Technical Problems in Sound and Television Broadcasting," by Dr. K. R. Sturley. South Wales Section. Cardiff College of Technology, Cathays Park, Cardiff. Wed., April 27, 6.30 p.m.

Chemical Society

LONDON
General Meeting. Thurs., May 5, 7.30 p.m.
EXETER
"Acetylene-Allene Chemistry," by Professor E. R. H. Jones. Exeter Branch. Washington Singer Laboratories, Exeter. Fri., May 6, 5 p.m.

Illuminating Engineering Society

LEICESTER
"Lamps and Lighting for Inspection," by H. E. Bellchambers. Leicester Centre. Offices of the East Midlands Electricity Board, Charles-street, Leicester. Mon., April 25, 6 p.m.
LIVERPOOL
Annual General Meeting and "A Survey of the Society's Activities," by the President, E. C. Lennox. Liverpool Centre. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Mon., May 2, 6.30 p.m.
NOTTINGHAM
Annual General Meeting. Nottingham Centre. Offices of the East Midlands Electricity Board, Smithy-row, Nottingham. Thurs., May 5, 6 p.m.

Incorporated Plant Engineers

LONDON
"Heat Pumps and Refrigeration," by Sir Oliver Lyle. London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., May 3, 7 p.m.
BIRMINGHAM
Discussion on "Locomotive Testing." Birmingham Branch. Imperial Hotel, Birmingham. Fri., April 29, 7.30 p.m.
LEEDS
"Admiralty Salvage," by W. D. Miller. West and East Yorkshire Branch. The University, Leeds. Mon., April 25, 7.30 p.m.

Institute of British Foundrymen

LONDON
Annual General Meeting and Apprentices' Evening. London Branch. Waldorf Hotel, Aldwych, W.C.2. Wed., April 27, 7.30 p.m.
BIRMINGHAM
"Developments in Mould and Core Making Processes, with Special Reference to the 'D Process' of Shell Moulding," by A. Tipper. Annual General Meeting. Birmingham Branch. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., April 27, 7.15 p.m.
LUTON
Annual General Meeting. Bedfordshire and Hertfordshire Section. Town Hall, Luton. Thurs., April 28, 7.30 p.m.
MANCHESTER
Annual General Meeting and Brains Trust on "Foundry Problems." Lancashire Branch. Engineers' Club, Albert-square, Manchester. Sat., April 23, 3 p.m.
SOUTHAMPTON
"Semi-Continuous Casting of Bronze," by Dr. E. C. Ellwood (with film). Annual General Meeting. Southampton Section. Technical College, St. Mary's-street, Southampton. Thurs., April 28, 7.30 p.m.
WELLINGBOROUGH
"Some Aspects of Shell Moulding Technique," by D. F. Bailey. Northampton Section. Hind Hotel, Wellingborough. Thurs., April 28, 7.30 p.m.

Institute of Fuel

LONDON
Presidential Address on "Fuel and Power Research in Britain," by Dr. W. Idris Jones. Institution of Civil Engineers, Great George-street, S.W.1. Wed., April 27, 5.30 p.m.
CARDIFF
Annual General Meeting. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., May 6, 6 p.m.

Institute of Marine Engineers

LONDON
"Safety at Sea," by Stewart Hogg. Student Lecture. Mon., April 25, 6.30 p.m.
Annual General Meeting. Tues., April 26, 5.30 p.m.

Institute of Metals

LONDON
"Statistical Methods in Metallurgy," by Dr. U. R. Evans. London Local Section. E.L.M.A. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Fri., May 6, 6 p.m.

Institute of Refrigeration

LONDON
"Some Problems in the Design of Household Refrigerators," by N. F. T. Saunders. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., May 5, 5.30 p.m.

Institute of Road Transport Engineers

DURHAM
Annual General Meeting. North-East England Group. Three Tuns Hotel, Durham City. Tues., April 26, 7 p.m.
GLASGOW
Annual General Meeting. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., April 25, 7.30 p.m.
NOTTINGHAM
Annual General Meeting. East Midlands Centre. Mechanics' Institute, Nottingham. Wed., May 4, 7.30 p.m.

Institution of Chemical Engineers

LONDON
Annual General Meeting. Presidential Address by Sir Harold Hartley. May Fair Hotel, Berkeley-street, W.1. Tues., April 26, 11 a.m.
"Plant Management," by P. M. Shaw. London Graduates' and Students' Section. Caxton Hall, Westminster, S.W.1. Fri., May 6, 6.30 p.m.

Institution of Civil Engineers

LONDON
"Potentialities of the British Railways System as a Reserved Roadway System," by Colonel T. I. Lloyd. Tues., April 26, 5.30 p.m.
"The Application of Prestressed Concrete to Water-Supply and Drainage," by Professor R. H. Evans. Public Health Engineering Division. Tues., May 3, 5.30 p.m.
LEEDS
"Geophysical Surveying Applied to Geological and Engineering Problems," by Professor J. T. Whetton. Yorkshire Association. Great Northern Hotel, Leeds. Fri., April 29, 7 p.m.

Institution of Electrical Engineers

LONDON
"The Taming of Graduates," by J. M. Armstrong. London Students' Section. Mon., April 25, 6.30 p.m.
"Automatic Circuit Reclosers," by G. F. Peirson, A. H. Pollard and N. Care. Supply Section. Wed., April 27, 5.30 p.m.
"The Adhesion of Electric Locomotives," by Dr. H. I. Andrews. Thurs., April 28, 5.30 p.m.
"A Simple Introduction to Telegraph Codes," by H. V. Higgitt. Radio Section. Mon., May 2, 5.30 p.m.
BIRMINGHAM
"Teaching Matrices to Part-Time Students," by Dr. W. E. Lewis. South Midland Education Discussion Circle. James Watt Memorial Institute, Great Charles-street, Birmingham. Fri., April 29, 6.30 p.m.
"Fuel Supplies of the Future," by E. F. Schumacher. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., May 2, 6 p.m.
LEEDS
Annual General Meeting and lecture on a non-electrical subject. North Midland Centre. Offices of the British Electricity Authority, 1 Whitehall-road, Leeds. Tues., May 3, 6.15 p.m.
MANCHESTER
"An Attracted-Disc Absolute Voltmeter," by G. W. Bowdler. Annual General Meeting. North-Western Centre. Engineers' Club, Albert-square, Manchester. Tues., May 3, 6.15 p.m.

Institution of Heating and Ventilating Engineers

LONDON
Annual General Meeting and Presidential Address. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., April 28, 6 p.m.
GLASGOW
Annual General Meeting. "Radiant Heating," by F. R. L. White. Scottish Branch. Scottish Building Centre, 425 Sauchiehall-street, Glasgow, C.2. Tues., April 26, 7 p.m.
LIVERPOOL
Annual General Meeting. Liverpool Branch. Radiant House, Bold-street, Liverpool. Tues., April 26, 6.30 p.m.

Institution of Locomotive Engineers

LONDON
"Operation and Running Maintenance of Locomotives on the Nigerian Railway," by F. H. Jaekel. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, SW.1. Wed., May 4, 5.30 p.m. (Alteration of date).

Institution of Mechanical Engineers

LONDON
"Heat Transfer to Liquids Boiling in Tubes, with Particular Reference to Refrigeration Evaporators," by Dr. R. J. Beale. London Graduates' Section. Tues., April 26, 6.30 p.m.
Discussion on "The Most Effective Way of Obtaining Close Co-operation Between Students and Teaching Staff." Education Group. Wed., April 27, 6.45 p.m.
James Clayton Lecture on "The Transport Helicopter," by Dr. I. I. Sikorsky. Fri., April 29, 5.30 p.m.
"The Reversible Bending of Turbine Shafts with Temperature," by A. Barker and Dr. F. W. Jones. Applied Mechanics Group. Fri., May 6, 5.30 p.m.
BRIGHTON
"Some Problems in Commissioning and Operating Brighton 'B' Power Station," by E. W. Ayling. Southern Graduates' Section. Brighton Technical College, Brighton. Wed., April 27, 7 p.m.
BRISTOL
"Matching a Diesel Engine to Light Road Vehicles," by M. Vulliamy. Western A.D. Centre. Royal Hotel, Bristol. Thurs., April 28, 6.45 p.m.
GUILDFORD
Annual General Meeting and Film Evening. Southern Graduates' Section. Guildford Technical College, Guildford. Fri., April 29, 7.30 p.m.
LEEDS
Chairman's Address by J. L. Hepworth. North-Eastern A.D. Centre. Chemistry Lecture Theatre, The University, Leeds. Wed., April 27, 7.15 p.m.

Institution of Production Engineers

MANCHESTER
"From Diamond to Spark Machining," by G. Tefer. Manchester Graduate Section. College of Technology, Sackville-street, Manchester. Mon., April 25, 6.45 p.m.
SHREWSBURY
"Manufacture of Springs," by John A. Roberts. Shrewsbury Section. Shrewsbury Technical College, Shrewsbury. Wed., April 27, 7.30 p.m.

Institution of the Rubber Industry

MANCHESTER
Annual General Meeting. Manchester Section. Engineers' Club, Albert-square, Manchester. Mon., April 25, 6.45 p.m.

Institution of Sanitary Engineers

LONDON
Open Meeting. Caxton Hall, Westminster, S.W.1. Thurs., May 5, 6 p.m.

Institution of Structural Engineers

LONDON
"Colliery Structures," by G. P. Bridges. Thurs., April 28, 6 p.m.

Iron and Steel Institute

LONDON
Annual General Meeting. 4 Grosvenor-gardens, S.W.1. Presidential Address, by Sir Charles Bruce-Gardner, Bt.; and "The Gas Turbo-Driven Blower for Blast-Furnace Service," by C. E. Sayer. Wed., April 27, 9.45 a.m.
"Charging Delays Due to Furnace Bunching," by R. Solt; and "The Supply of Scrap to Open-Hearth Furnaces," by M. D. J. Brisby and W. O. Pendray. Wed., April 27, 2.30 p.m.
"Causes of Variable Creep Strength in Carbon Steel," by W. E. Bardgett and M. G. Gemmill; "Creep and Rupture Data on Mo, Cr-Mo and Mo-V Steels," by J. Glen; "Statistical Study of Creep and Fatigue Properties of a Precision-Cast High-Temperature Alloy," by G. T. Harris and H. C. Child; and "Relationships Between Long and Short Time Creep and Tensile Properties of a Commercial Alloy," by A. Graham and K. F. A. Walles. Thurs., April 28, 10.30 a.m.
"Mechanism of Accelerated Attack on Metals and Alloys by Vanadium Pentoxide," by G. Lucas, H. Weddle and A. Preece; and "Effect of Composition of Gas-Turbine Alloys on Resistance to Scaling and to Vanadium-Pentoxide Attack, by G. T. Harris, H. C. Child and J. A. Kerr. Thurs., April 28, 2.30 p.m.

Royal Aeronautical Society

LONDON
"Aerial Systems for Aircraft," by R. A. Burberry. Tues., April 26, 7 p.m.
"Plastic Structures," by G. C. Hulbert. Tues., May 3, 7 p.m.
"Technical Aspects of Supersonic Aircraft Design," by E. J. Catchpole and W. J. Eggington. Graduates' and Students' Section. Wed., May 4, 7.30 p.m.

Royal Institution

LONDON
"Fast Reactions in Solids and the Birth and Growth of Explosions," by Dr. F. P. Bowden. Fri., May 6, 9 p.m.

Royal Meteorological Society

LONDON
Symons Memorial Lecture by Professor A. C. B. Lovell. Wed., April 27, 5 p.m.

Royal Society

LONDON
Bakerian Lecture on "The Acceleration of Charged Particles to Very High Energies," by M. L. E. Oliphant. Thurs., April 28, 4.30 p.m.
Discussion on "Magneto-Hydrodynamics," to be opened by Sir Edward Bullard. Thurs., May 5, 10.30 a.m.

Royal Society of Arts

LONDON
"Commonwealth as a Source of Essential Oils," by M. F. Carroll. Commonwealth Section. Thurs., April 28, 5.15 p.m.
Trueman Wood Lecture on "New Ways of Flying," by Major Oliver Stewart. Wed., May 4, 2.30 p.m.

Royal Statistical Society

LONDON
"Statistical Methods in Metallurgy," by Dr. U. R. Evans. London Industrial Applications Group. E.L.M.A. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Fri., May 6, 6 p.m.
LEICESTER
Annual General Meeting. Leicester Industrial Applications Group. Bell Hotel, Leicester. Thurs., April 28, 7 p.m.
SHEFFIELD
Annual General Meeting. "Labour Wastage in an Industrial Concern," by Dr. J. E. Andrew. Sheffield Industrial Applications Group. Grand Hotel, Sheffield. Thurs., April 28, 6.30 p.m.

Society of Chemical Industry

LONDON
Annual General Meeting. Chairman's Address on "Some Thoughts on the Practice of Applied Science," by Dr. J. C. Hudson. Corrosion Group. Chemical Society's Apartments, Burlington House, Piccadilly, W.1. Wed., April 27, 6.30 p.m.

Society of Instrument Technology

LONDON
"Magnetic Amplifiers as Industrial and Laboratory Aids," by R. J. Russell-Bates. Manson House, 26 Portland-place, W.1. Tues., April 26, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Refrigeration, Dalmeny House, Monument-street, London, E.C.3. (MINcing Lane 6851.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Sanitary Engineers, 118 Victoria-street, London, S.W.1. (VICtoria 3017.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. (SLOane 0061.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Society of Chemical Industry, 56 Victoria-street, London, S.W.1. (VICtoria 5215.)
Society of Instrument Technology, 184 Sherwood Park-road, Mitcham, Surrey. (POLlards 3620.)